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Agro-Landscape zoning of West Georgia for revealing of optimal regions of tangerine - Tiakhara Unshiu

KEYWORDS: agri-resource potential, Control Species, etalon-object, Geographical Zoning, landscapes, Phenological phases

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ABSTRACT *Based on the metrics suspended in factors area, techniques (Seperteladze Z et al., 2012; Urushadze T et al., 2012) for agricultural coverage of the territory and rational planting of the citruses of humid subtropical zone of the west Georgia, including verification of their agro potential were developed. Morphometric analysis (biometric index, starting-ending point of the first and second growth, starting-ending point of blossoming, starting of ripening and massive ripening, harvest, mechanical and biochemical composition of the fruit, tasting, storage properties, cost-effectiveness and frost (winter) resistance) of the tangerine – Tiahara Unshiu, introduced from Japan was accomplished. Aforementioned techniques helped to allocate and differentiate various resource territories, following the resemblance with the virtual model-object and allocation of the landscapes with and administrative units with optimal agro potentials. Data was processed and visualized through GIS – technologies.*

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1. Introduction

In terms of production, citrus takes second place in the world. Citruses are cultivated in more than 75 countries of the populated continents. It is surpassed by vine culture, as a result of its multi purpose usage.

In Georgia, for cultivating of citruses, landscape response towards such problems is very important in terms of general background of the global climate changes (Elizbarashvili N et al., 2014). Thereby, response of humid landscapes of the west Georgia differs from Semiarid and Arid landscapes of the east Georgia. Temperature drop-down tendency and other negative natural processes of humid landscapes of the west Georgia should be taken into account, when cultivating citruses and verifying of their frost resistance level. This is proved by the fact, when in 1885 tangerines imported from Italy to Georgia for the first time failed to be launched in cultivation because of its pure frost resistance level (Khans S and Engelman D, 2006). 4). In recent years, it became quite clear that old tangerine species are degrading and it is tome to replace them with new species (Tiahara Unshiu and Georgian Early ripe "Saadreo"), distinguished with successful frost resistance, in the beginning of October.

Notwithstanding the limited climate conditions, citrus-cultivation is considered to be highly intensive and effective field (Agricultural sector 2011, Geography of Georgia 2003). Tangerine takes the first place among citruses, based on coverage area and important, conditioned by its high frost resistance and cost-effectiveness. Citrus-cultivation is non-traditional field of the agriculture of Georgia.

The following is agro climate index for citrus cultivation in Georgia:

- Total of active temperatures – more than 4000^0
- Minimum monthly humid balance - 1.0
- Average of annual absolute minimums of air temperature -4^0
- Average temperature of the coldest month +4, $+7^0$

It is known that, for cultivating and productivity of any agricultural product, warmth and humidity are the most important factors, namely, interaction of temperature index and humidity coefficient – hydrothermal coefficient (Table 1), though other physical – geographical conditions (orohydrographical and soil) have important role as well. In this term, Georgia is distinguished and namely its west part.

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For the fact that, major part of the west Georgia (Kolkheti) is open from the west side and it is walled by medium and high mountains from other three sides, Kolkheti is characterized by: large humidity, high air temperatures, high index of sun radiation and illumination duration, seasonal changes of the west and east winds, advection of cold airs, resulting in sharp change of the weather conditions, etc. All the aforementioned affect on growth, development, productivity and geographical distribution of the agricultural products.

Table 1. Hydrothermal coefficients of the vegetation period (HTC) of different provision

HTC	Provision, %				
	90	75	50	25	5
1.5	1.0	1.3	1.5	1.9	3.1
2.0	1.5	1.8	2.0	2.6	4.7
2.5	1.9	2.3	2.5	2.9	5.0
3.0	2.2	2.6	3.0	3.6	5.5
3.5	2.5	3.0	3.5	4.0	5.9

Notwithstanding that, west Georgia is distinguished by high level of cloudiness and excess of precipitations, high illumination between 1800-2300 hours, total sun radiation up to 120/130 kkal/cm^2 per year.

Average air temperature is 14-15^0 in lower part, in mountainous part it is 12-13^0. Average temperature of the coldest month – January is positive everywhere and it is 4-6^0 at waterside, at foothills +2, +3^0. In case of cold airs (which is not rare in recent period), absolute minimum temperature drops to -9, -10^0 at waterside.

Considering critical temperatures (Table 2 and Figure 1), namely according to the relativity of temperatures, there was revealed possibility of citrus damage in different regions and we have received the following picture: in -4^0 zone (Black Sea waterside) lemon damage is to be expected once per 4 years (25% possibility), in -6^0 zone, orange "Washington Naveli" may be damaged once per four years and as for the tangerine – Unshiu, it can be damaged very rarely – once per 20 years (5% probability).

Table 2. Probability of Minimum Air temperature

Average of Abs. Minumum	Probability of minimum, %				
	5	25	50	75	90
-4	-10	-7	-4	-2	1
-6	-12	-9	-6	-4	-1
-8	-14	-11	-8	-6	-3
-10	-16	-13	-10	-8	-5

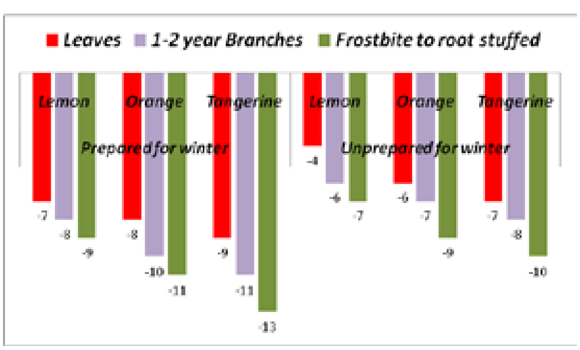

Figure 1. Critical Temperatures of Causing citrus damage

Slight slope of relief and close location to the sea incurs different direction and speed of the winds in Kolkheti. Subtropical cultures are especially damaged in winter by cold eastern wind and in summer by so called dry Foehn winds, causing fading of leaves and falling of the fruit, though it can have positive importance as well, as they balance air humidity, partially drying out excessively humid soil, etc.

Practitioners (Meladze G and Meladze M 2012, Sepertеladze Z et al., 2014) have verified that vegetation of citruses starts approximately in 10^0 temperature conditions, thereby blossoming of tangerine starts during 17^0 average overnight temperatures, and ripening at 12^0. Orange requires almost similar conditions; though it is more demanding towards warmth, for example, lemon needs 4000^0 on average, during the vegetation period, tangerine needs 4200^0, whereas orange needs 4500^0.

Frost-resistance of citrus cultures directly refers to its composition of dry materials; whereas as much dry materials are in the plant, as frost resistance it is. This, the most tender plant is lemon, its leaves are damaged at -8, -6^0, at -7^0 tree crown is damaged, and at -9^0 it dies out completely. Japanese species of tangerine shows special frost-resistance, namely (Unshiu), standing -8^0 frosts, though at -12^0 it may die out completely. One of the important features of frost-resistance is to prepare the plant for winter i.e. "training", which successfully continues, as seasonal dropping down of temperature is gradual. It is also necessary to launch additional actions: selective, agro technical and ecologic. Thus, present article focuses exactly on the later two factors, in terms of Japanese specie of the tangerine – Unshiu.

From the tangerine species spread through the Black Sea waterside subtropical zone, broad-leaved Unshiu showed vast industrial importance up to the present day; Unshiu got well adapted with local soil-climate conditions, delivering rich and stabile harvest if well cared. Consuming suitability of the fruit begins from the first decade of November and lasts until the end of this month and fruit-consuming is verified as of one calendar month, which is not optimal (Lamparadze Sh., 2002), as in late autumn, because of comparably low temperature and variable weather conditions, fruit cannot ripe in time, thus consuming and realization of fruits are decreased. Thus, this tangerine specie bears high risk and we have studied (Lamparadze Sh., 2008), some agricultural and biological characteristics of new tangerine specie, introduced from Japan (Tiahara Unshiu) based on these studies, this specie was introduced in Achara-Guria and Samegrelo citrus zone, as early ripening, fruitful and the best specie, by the State Commission of Testing Agricultural Products of Georgia. Selecting-ranging of the territories offering optimal conditions for the aforementioned tangerine was carried out via mathematical method. Namely, evaluation of agro-climate characteristics (selecting-processing), creating of virtual model and landscape zoning of territory according to the model, for evaluating possible conformance of its natural conditions.

Agro resource evaluation of territory is extremely important for rational planting and revealing of potential high productivity of cultures. Later depends on many factors, including the most important one, natural, physical-geographical factor, being multi angle and multidimensional. We decided to solve such a difficult task via mathematical device (Klitsunova N 2007, Nikolaishvili D et al., 2013), allowing perfection of geographical approach and thus, giving more equitable, complex evaluation of the territory.

Based on the aforementioned methods, authors of the present article focused on subtropical cultures cultivated in west Georgia. Notwithstanding that it's been long time

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that tangerines are introduced in Georgia, it blossoms really well and gives rich harvest in west Georgia – Achara-Guria, Samegrelo, Abkhazia and partially, on lower and hilly zones of Imereti (500 m above sea level). Issues of perspective optimal landscape zoning of these cultures are not yet studied. Thus, we, the group of authors, in cooperation with the practitioner – agro technicians, processed and estimated agro-climate index of tangerine – Unshiu, including selecting and revealing of optimal natural conditions (without accomplishing any agro action) (by creating a sample model), scientific grounding of its cultivation and landscape zoning of territory, based on GIS – analyzes.

2. Research Methods and Initial Data

There are different methods and principles of studying of multi factor analysis. Each of them plays a varied role according to its significance. An evaluation of agri-resource potential of a particular territory requires multi factor analysis too. Therefore, it is important to select a method which will maximum ensure the correct assessment of current situation. From this point of view, on the one hand it is important to take into account the entire complex of factors (Khans S and Engelman D 2006, Arkhipov U., et al 1986), but on the other hand - to demonstrate the leading factor. From the above mentioned, for evaluation of agri-resource potential is relevant to determine the weighted distance from various territorial units to the etalon-object (mark and feature) by considering the priority factors, grouping of objects according to the etalon object closeness value (Viktorov A 2006, Seperteladze Z 2014).

The research was conducted in several stages:

To create the DB for determination of indicators of agri resource potential. Data have been grouped according to three categories: administrative units (11 regions), different altitudes (8 levels 0-50, 50-100, 100-200, 200-500, 500-800, 800-1000, 1000-1500, 1500-2000, and more than 2000 m) and of landscapes (71 species).

On the basis of the program MATLAB and consideration of the priority factors from each object to etalon-object were calculated weighted distances, and they were grouped according to Sturges' formula.

According to a series of maps of GIS have been revealed the features of territorial distribution for the closeness value to etalon-object and also have been determined those administrative units, different altitudes and landscapes, which have a maximum agri resource potential.

Evaluating the landscapes for the agricultural purpose, the nature components and parameters, which make basic influence on it, should be viewed in details. This will be a pre-requisite for detection of the events and processes, which significantly influences on agricultural production. (Seperteladze Z 2009).

The research was based on factors determining the agri resource potential: the sum of active air temperature (>10^{0}C), the annual amount of atmospheric precipitations (mm), relative humidity of air (%), air humidity deficit (mb), duration of period without frost (number of days), hydrothermal coefficient, altitude.

For determining of agri-resource potential of landscapes some other parameters were took into account too. These parameters are: humus amount in the A and B horizons or in the 1 m layer, and productivity of vegetation..

Data processing was carried out with the mathematical models in several stages:

- Formation of Matrix $A = (a_{ij})_{n \times m}$, where $a_{ij} = K_j(O_i); i = \overline{1,n}, j = \overline{1,m}$ (1)

$O_1, O_2, ..., O_n$ and $K_1, K_2, ..., K_m$ appropriately determine objects (territorial units) and selected quantitative characteristics in accordance with the aim of redistricting process.

Data normalizing, because of range of numerical values variations corresponding to marks and features may differ from each other by several row.

$$k_j(O_i) = \frac{K_j(O_i)}{K_j^*}, i = \overline{1,n}, j = \overline{1,m},$$

where

$$K_j^* = \max\{K_j(O_1), K_j(O_2), ..., K_j(O_n)\}, j = \overline{1,m} \quad (2)$$

Composition of normalizing data matrix

$$B = (b_{ij})_{m \times n}, b_{ij} = k_j(O_i), i = \overline{1,n}, j = \overline{1,m} \quad (3)$$

$c_j, j = \overline{1,m}$

Determination of priority coefficient for i-characteristic , wh e r e

$$\sum_{j=1}^{m} c_j = 1, \quad (4)$$

Formation of normalized values

$$e_i = \frac{E_j}{K_j^*}, j = \overline{1,m}, \quad (5)$$

where E_j ($j = \overline{1,m}$) are the components of etalon-object

Calculation of ,,weighed'' distances from O_i object to E etalon-object in Euclid n dimension space:

$$d_i = \sqrt{\sum_{j=1}^{m} c_j (b_{ij} - e_j)^2}, i = \overline{1,n} \quad (6)$$

Determination of full range of distance dispersion from the object to etalon $d_{max} - d_{min}$,

where $d_{max} = \max\{d_1, d_2, ..., d_n\}$,

$$d_{min} = \min\{d_1, d_2, ..., d_n\}. \quad (7)$$

$k = 1 + 3{,}222 \log n$

By Sturges formula (Khans, Engelman 2006) for *n* optimal amount of grouping of objects were determined and determination of verge of grouping intervals:

$$h = \frac{d_{max} - d_{min}}{k}, \quad (8)$$

On the basis of complex characteristics the intervals for grouping of objects was defined:

$$(rd_{min}, rd_{min} + h), r = \overline{1,k}. \quad (9)$$

Based on the obtained, to take into consideration the entire complex of mark and features, in the first category r=1

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are the objects that are most close to the etalon-object, but in category r=k-objects that are far from the most.

In some of the works, we may see a different approach to the complex evaluation problem solving of the territorial units. In this regard, our present model is specific and has a number of advantages, which can be grouped:

The possibility of consideration of mark and features different nature (in regard with types and values of measurement and range variations of scales).

The introduction of weighted measure by the priority coefficient of mark and features of the closeness value to the object.

Model universality in the sense that it can be used as for the evaluation of separate agriculture so for the evaluation of complex agri resource potential, when the problem of grouping and selection of the optimal objects is solved by simultaneous consideration of multiple criteria.

Time-consuming calculation should be considered as the faulty part of the model, especially with the increase of mark and features. However, it should be noted that by consideration of modern technologies and software capabilities, the current problem can be solved successfully.

The advantage of this method lies in the fact that it can be used in other similar multi-factored geographical analyses, such as selection of analogue objects and optimal conditions on the bases of several criteria, as certain the degree of anthropogenic transformation of the territory and other. However, the method has fault parts what for the first relates to agri resource potential with respect of assigning various ranks to almost equal importance objects. The most important role in achieving accurate results fulfils the correct selection of agri resource potential determining factors and their meanings as well as determining correctly their meanings (ranks).

A special interest is paid to landscape approach, which implies complex-geographical studies.

The research is based on the use of the landscape map of the Caucasus, where the smallest classification unit is the landscape species (Nikolaishvili D. 2008, Nikolaishvili D and Matchavariani L 2010). Agri-meteorological data were based on the climate reference books (The conception of the development of Agriculture of Georgia 2012).

As, in-depth research of morphological and biological features of the plants is a must for revealing potential possibilities of specie adaptation in changing natural conditions, analysis of Tiahara Unshiu – tangerine, introduced from Japan, including Georgian selective species, was accomplished in terms of numerical and exterior indexes of plant parts (plant height, diameter, general form, color of fruit skin and flesh, thickness of the skin, juiciness, etc), via following evaluation plan: shoot of the plant was measured via natural measuring. Leafed part of the crown was calculated via following formula: , where D is the average diameter of the crown, H is plant height; we measured the plant at 4 cm from engrafting place, and used formula for calculation of leaf space (Lamparadze Sh 2008).

Biological characteristics of controlling and testing plants were accomplished through phonological observations (starting-ending point of the first and second growth, starting-ending point of blossoming, starting of fruit ripening and massive ripening).

For researching quality index of the fruit, sugar content was verified via Bertrand's method, vitamins via Murr method, total acidity – via titration method. Frost resistance of the plants was verified by frosting two years plants and cut branches in artificial climate laboratory, etc.

As, introduction of frost-resistant tangerine species are very important for humid subtropical zone, we've studied frost-resistance capabilities via modeling methods, namely, in simulated climate laboratory, both with two year plants in vegetation vessels and cut branches (Figure 2).

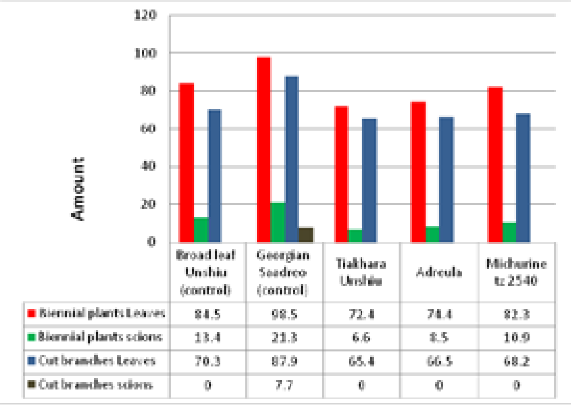

Figure 2. Cultivated and Georgian selective varieties Tangerine relative resistance - Freeze 9^0 temperatures, damage in % (3-year average data)

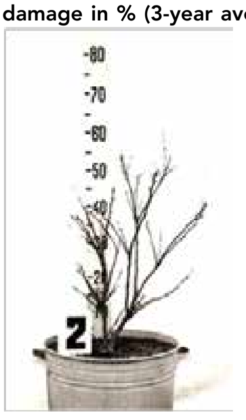

Figure 3. Tangerine varieties - Georgian "Saadreo" 2-year plant after - 9 ° C- freeze

Figure 4. Tangerine varieties - Tiakhara Unshiu 2-year plant after - 9 ° C- freeze

There is also difference between separate tangerine species in terms of mechanical and biochemical index (Table 3). Tiahara Unshiu gives the largest fruit – 79.8g and Georgian Early ripe "Saadreo" – 73.8 g, whereas broad-leafed Unshiu and Georgian "Saadreo" (Early ripe) weighs 59.6 and 73.8g, respectively.

Table 3. Cultivated and Georgian selective varieties Tangerine Mechanical and biochemical composition of the fruit (5-year average data)

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#	Variety name	Mechanical composition %					juice composition in 100 milliliters calculation				Sugar Acidity ratio	Degustation Rate (Intensity)
		average weight of the fruit, g	Skin	Pulp	The yield of juice: from pulp	The yield of juice: From fruit	Dry substance,%	Citric acid, calculated on its titratable acidity	Vitamin C mg/%	Sugar sum		
1	Broad leaf Unshiu (control)	59.6	28.7	71.3	70.0	51.1	9.1	1.04	35.6	7.6	7.3	75.1
2	Georgian Early Ripe, "Saadreo" (control)	73.8	26.9	73.1	63.8	46.2	9.2	1.13	36.9	7.8	6.9	75.9
3	Tiakhara Unshiu	79.8	24.1	75.9	74.0	55.6	9.3	0.91	38.1	7.9	8.7	80.2
4	"Adreula" (early ripe)	71.1	27.4	72.6	69.0	49.9	9.6	1.11	34.7	7.8	7.0	78.6
5	Michurinetz 2540	69.5	29.5	70.5	71.3	50.5	9.6	1.17	33.6	7.7	6.6	73.9

Tangerine Tiahara Unshiu, introduced from Japan doesn't need some special agro technical measures, thus expenses for 1 h cultivation and nursing are not different from the same expenses of the Georgian selective species.

Cost-effectiveness of tangerine species depends on the following specifications: hectare productivity, expenditure on total production, nominal price of unit product and total net profit (Table 4).

Table 4. Georgian selective varieties of mandarins and introduced major economic indicators in hectare (10-year average data)

#	Variety name	Productivity c/h	Total production value (USD)	Total expenses (USD)	1 quintals of production cost (USD)	Net Income (USD)
1	Broad leaf Unshiu (control)	424	12863	6917	16.3	6471
2	Georgian Early ripe "Saadreo" (control)	455	14368	7184	15.78	7184
3	Tiakhara Unshiu	552	17431	7263	13.15	10168
4	"Adreula" (early ripe)	538	16989	7362	13.68	9627
5	Michurinetz 2540	513	16200	7560	14.73	8640

As table 4 shows, in terms of cost-effectiveness, the following tangerine species are more attractive and interesting: Tiahara Unshiu, Early ripe (Adreula) and Michurinetz 2540, which comparing with broad-leafed Unshiu bring up to 34% - 57% additional profit per hectare and in comparing with the Georgian Early Rip "Saadreo" 20%-42%.

Thus, profitability level of introduced tangerine Tiahara Unshiu and Georgian selective species: Adreula and Michurinetz 2540 reaches 114-140%, when controlling species shows only 94-100% (broad-leafed Unshiu, Georgian Early Ripe "Saadreo").

Correspondingly, for agricultural profitability, natural (landscape), namely, agro climate resources (duration of sun illumination, total of active temperatures, precipitations, humidity of soil and air, etc) should be used as much as possible, based on which, aforementioned characteristics can be used effectively in different regions, aiming developing of agricultural products and their rational distribution-planting (zoning) - . We have marked out 7 agro climate zones (Urushadze T 2012) in west Georgia (Figure 5, Table 5).

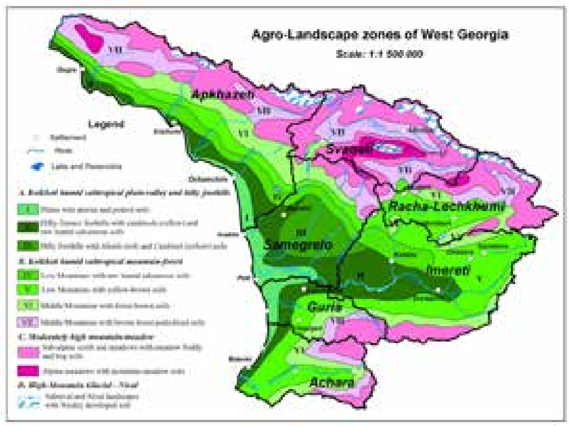

Figure 5. Agro-Landscape Zones of West Georgia

Table 5

Zone	Altitude from sea level (m)	Actual temperature total (more than 10%)	Average of absolute and minimal temperature (oC)	Nonfreezing days
I	0-350	4000-4500	-3	280-310
II	351-560	3500-4000	-14-16	190-275
III	561-780	3000-3500	-18-8	186-267
IV	781-990	2500-3000	-12-22	175-216
V	991-1250	2000-2500	-14-23	140-205
VI	1251-1750	1500-2000	-15-28	120-180
VII	1751-2100	1000-1500	-19-29	100-150

Based on the data base received from accomplished studies (Seperteladze Z 2014), it was verified that 3 agro climate zones (I, II, III) are distinguished with suitable physical – geographical (soil-climate) conditions for cultivation of

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citrus cultures in west Georgia (Table 6).

№	Horizon, depth, cm	pH	Humus, %	Exchangeable cations, mgq/ 100 g. s.							<0.001	<0.001	Fe203	
				Ca	Mg	H	Sum	% of Sum					Amorp.	Noncrist.
								Ca	Mg	H				
Subtropical podzols														
1	A – 0 - 14	6.1	3.84	19.25	7.73	0.99	27.47	69	28	3	33	69	1.55	3.88
	A2(f)-14-26	5.6	1.90	5.14	4.02	1.98	11.14	46	36	18	31	69	1/55	3.45
	A2Bfg-25-38	6.0	0.53	2.60	0.74	3.96	7.30	36	10	54	32	74	0.98	2.16
	Bg 35 - 65	5.4	0.37	16.22	2.96	4.96	24.14	67	12	21	38	75	0.93	2.88
	BCf(g) -65-90	5.4	0.19	13.73	4.85	0.99	19.70	70	28	2	42	59	1.16	2.16
5	A – 0 - 15	4.6	2.64	2.20	1.48	1.98	5.66	39	26	35	19	60	0.98	2.63
	A1A2 –15-28	5.2	1.49	4.04	0.33	1.98	6.35	64	5	31	39	61	0.85	2.54
	B – 28-50	5.3	1.22	2.89	0.33	0.99	4.21	69	8	23	29	66	0.84	1.83
	BC(f)-50-90	5.3	0.86	3.99	1.33	1.98	6.30	63	5	32	21	60	1.07	2.13
Yellow soils														
7	A – 1 – 12	4.6	6.51	6.48	4.43	3.71	14.62	44	30	26	18	45	1.32	3.04
	AB – 12 – 24	5.2	2.05	3.88	1.73	4.53	10.14	38	17	45	19	47	1.40	3.31
	B1 – 24 – 38	4.8	1.25	2.81	2.05	7.95	12.81	22	16	62	19	48	1.55	3.51
	B2 – 38 – 50	4.9	0.85	3.24	2.27	12.15	17.66	1 8	13	69	20	49	1.65	4.00
	BC – 50 - 80	4.7	0.20	4.54	4.75	15.21	24.50	18	19	63	22	49	1.80	4.66
9	A – 1 - 10	5.4	4.35	11.14	5.78	1.96	18.88	59	31	10	20	46	1.10	2.30
	AB – 10 - 22	4.9	1.82	15.71	10.98	7.12	33.81	46	32	22	21	47	1.28	2.75
	B1 – 22 - 36	5.2	0.94	18.63	12.24	5.56	36.43	51	34	15	22	52	1.20	2.21
	B2 – 31 - 55	5.4	0.63	20.44	14.33	2.80	37.47	54	38	8	22	53	1.08	1.59
	BC – 55 - 90	6.3	0.15	29.48	15.02	0.40	44.90	66	33	1	24	54	1.01	1.34

In 1980 in Achara region, tangerine held 4500 ha and now it is 5600 ha, Citrus cultivation Led to the destruction of Kolkheti Poly-dominant forests in Achara and in Whole west Georgia up to 500-600m. Their particular areas can be found in deep gorges and in protected areas.

Achara is mountainous region, where the forests and bushes cover 191 thousand ha, which is 66% of the total area. 23289 ha come on Khelvachauri Municipality and 23279 ha of Kobuleti Municipality (2010 statistics).

The total area of bushes and forests in Khelvachauri and Kobuleti Municipality bellow 300m covers 763 and 1215ha respectively, where the tangerines have the best soil and climatic conditions. In recent years, the area of bushes increased at the expense of tea plantations desolation (destruction).

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Main agricultural crops in Kobuleti and Khelvachauri Municipalities are tea and citrus, but in the 90s by the difficult economic situation in the country drastically reduced the tea plantations and Citrus plantations were considerably reduced.

In 1990, from 8529 hectares of citrus, were produced 152730 tons of fruit, and in 2000 it was received 39320 tons from the 7895 hectares. Fruit. Citrus plantations declining trend continued until 2005, which was mainly due to the sale of fetal problems, incorrect land privatization and cultivation other perennial crops (nuts, kiwi, blueberry). Today there are 4,500 ha of citrus plants produce about 100-110 thousand tons of fruit, which is about 22-25 tons per ha per annum. Low productivity is considered that it is needed to update variety, which should be replaced by High-yield productivity varieties. It is in these sorts of Tangerine Tiakhara Unshiu appears that good agricultural background in the 50-60 tons per hectare harvested.

In Industrial plants 95% holds Tangerine broad leave Unshiu, the remaining 5% hold other breeds (Georgian Early Ripe "Saadreo", Kovano-Vase, and et. al).

For improvement of the range of breed and productivity in Achara citrus farmer farms it is implemented Tiakhara Unshiu Tangerine, which gives 30% more fruits and brewing 30-35 days early as usual tangerine.

Since 2005, the number of Tiakhara Unshius is increasing every year, today it is55 hectares. The new species of shrubs and plants are built mainly former tea areas, on removed old bushes and trees (amortized) place.

In Kobuleti and Khelvachauri municipality it can be planted 30-35 hectares of new plantations of Tiakhara Unshiu tangerines every year, for which there are farms of micro-nurseries, where it is possible production of 35-40 thousand high-quality implants of Tiakhara Unshiu annualy.

For cultivation of citrus, place with the most suitable natural conditions is Achara. Generally, there are 5 agro climate zones in Achara, whereas two of them is most suitable in terms of citrus cultivation and high productivity – in 500-500 m above sea level: I zone (50-200 above sea level) – total of active temperatures more than 4000^0; number of precipitations in warm period of the year is 1360-1500mm; last frosting -4; III -15. III, first frosting -2. XII -7. I.; number of frost free days – 246-304; dominating soil type – subtropical podzol, red soils and alluvial; II zone (200-500 m above sea level) is more vast and mainly includes Kobuleti and Khelvachauri Municipalities. Total of active temperatures is 3000-4000^0; precipitations in warm period of the year is 800-1330mm; last frost -13. III -26. III, first frost -6. XII -1. I.; number of frost free days -255-273; dominating soil type – red soils and yellow soils.

Second region in terms of subtropical natural condition is Abkhazia (Table 7). Only two from five climate zones allows cultivating subtropical cultures and receiving quality product.

Table 7. Basic agro-climatic characteristics

Mete-orological station	Height (m)	Sum of active temperatures (≥ 100)	Amount of Precipitation, mm	Relative Humidity of air, %	Air humidity deficit, Mb	Frost-free days	HTC
Akhalsheni	100	4300	1470	78	5.0	304	3.4
Batumi	15	4320	1440	80	4.7	302	3.3
Keda	290	3880	800	77	5.4	257	2.0
Kobuleti	5	3990	1360	81	4.3	246	3.4
Chakvi	15	4230	1500	80	4.7	282	3.5

I zone – includes water side and lower hilly regions (50-300 m above sea level). Total of active temperatures more than 4000^0; precipitations in warm period of the year are 710-1010mm; last frost -10. III – 20. III, first frost -13. XII-25. XII.; number of frost free days 269-291; dominating soil type – subtropical podzol, yellow podzolic soil, yellow soil and red soils. II zone (300-500 m above sea level). Total of active temperatures 3000-4000^0; precipitations in warm period of the year are 1100-1400 mm; last frost -25. III -28. III, first frost – 2. XII -6. XII.; number of frost free days – 251-260; dominating soil type: red soils – podzolic, yellow soil – podzolic, subtropical podzol, carbonate.

In west Georgia, Guria is the part distinguished with humid subtropical conditions and generally, we have 5 agro climate zones here, two of them are subtropical (Table 8).

Table 8. Basic agro-climatic characteristics

Meteorological station	Height (m)	Sum of active temperatures (≥ 100)	Amount of Precipitation, mm	Relative Humidity of air, %	Air humidity deficit, Mb	Frost-free days	HTC
Gagra	25	4330	710	79	5.1	273	1.6
Gali	48	4260	970	81	5.1	250	2.3
Gudauta	46	4430	790	77	5.6	288	1.9
Duripshi	260	4100	1010	76	5.9	263	2.5
Gulripshi	20	4400	820	75	5.8	294	1.9
Ochamchire	5	4150	770	84	4.0	262	1.8
Sokhumi	7	4060	820	78	5.4	295	1.8

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I zone (50-200 m above sea level) includes water side and lower hilly regions: total of active temperatures is more than 4000^0; precipitations in warm period of the year are 1000-1370mm; last frost -10. III -18. III, first frost -16. XII -25. XII; number of frost free days – 274-290; dominating soil type – subtropical – podzol, alluvial –acid, red soils. II zone – (200-500 m above sea level) shows the following characteristics: total of active temperatures is 4000-3500^0; precipitations in warm period of the year are 9000-1200mm; last frost -15. III -20. III, first frost-10. XII-20. XII; number of frost free days – 250-270; dominating soil type: podzol – gleysols, yellow soils, red soils.

In Samegrelo, only two zones from 5 agro climate zones are having physical-geographical conditions suitable for subtropical cultures (Table 9), 50-500 m above sea level.

Table 9. Basic agro-climatic characteristics

Meteorological station	Height (m)	Sum of active temperatures (≥ 100)	Amount of Precipitation, mm	Relative Humidity of air, %	Air humidity deficit, Mb	Frost-free days	HTC
Anaseuli	70	4150	1140	79	4.0	277	2.7
Acana	160	4020	1130	80	5.0	272	2.8
Dablatsikhe	250	4160	980	74	6.3	272	2.3
Supsa	5	4060	1370	83	4.2	267	3.3
Ureki	10	4380	1180	80	4.6	288	2.7

I zone - includes Black Sea water side and lower hilly regions (50-200m above sea level). Total of active temperatures is more than 4000^0; precipitations in warm period of the year are 800-1160mm; last frost -15. III -20. III, first frost – 2. XII – 7. XII.; number of frost free days – 252-260; dominating soil type – red soil – podzolic, peat bog, yellow soils. I zone (200-500 m above sea level); total of active temperatures – 3700-4200^0; precipitations in warm period of the year are 1160 -1220mm; last frost -21. III -29. III, first frost -23. XI – 6. XII; number of frost free days – 236-257; dominating soil type – yellow soil – podzolic, subtropical podzol. In comparing with other regions, Imereti region of the west Georgia gives less suitable physical – geographical conditions for cultivation of subtropical cultures (Table 10) and that is why, we have only one subtropical zone (hypsometric first) here.

Table 10. Basic agro-climatic characteristics

Meteorological station	Height (m)	Sum of active temperatures (≥ 100)	Amount of Precipitation, mm	Relative Humidity of air,%	Air humidity deficit, Mb	Frost-free days	HTC
Abasha	24	4310	790	81	2.2	270	1.8
Anaklia	3	4250	900	83	1.8	263	2.1
Zugdidi	100	4160	1010	79	2.0	250	2.4
Martvili	180	4210	1110	76	1.2	257	2.6
Mukhuri	270	4260	1430	73	2.5	276	3.3
Senaki	31	4520	1000	76	2.7	288	2.2
Tsalenjikha	200	4000	1160	77	2.6	255	2.9
Kheta	80	4560	1100	78	3.0	275	2.4
Chkhorotsku	180	4130	1200	77	2.7	250	2.9

I zone includes plain of lower Imereti and hilly part of upper Imereti (200-300 m above sea level). Total of active temperatures is more than 4000^0; precipitations in warm period of the year are 600-1000 mm; last frost -2. III-5. III, first frost -25. XI-30.XI; number of frost free days -251-274; dominating soil type – alluvial –carbonate, subtropical – podzol, carbonate, yellow soils (Table 11).

Table 11. Basic agro-climatic characteristics

Meteorological station	Height (m)	Sum of active temperatures (≥ 100)	Amount of Precipitation, mm	Relative Humidity of air, %	Air humidity deficit, Mb	Frost-free days	HTC
Dimi	180	4300	670	72	7.5	278	1.5
Vani	70	4330	680	74	7.0	278	1.5
Sakara	55	4330	600	72	7.9	250	1.4
Samtredia	25	4470	750	77	6.4	284	1.6
Tskaltubo	120	4500	990	75	7.3	253	2.2
Chiatura	400	4090	600	73	7.2	255	1.4
Kharagauli	350	4090	730	73	7.8	245	1.7
Khoni	120	4410	1000	76	6.9	272	2.2

3. Main results

Based on the experiment – morphological researches and resemblance with the sample-model, pursuant to the accomplished physical – geographical zoning, the following results are marked out:

1. Techniques for evaluating agro potential of territorial units via mathematical device were developed, standing on calculation of suspended distances via factor priority potential to sample-model;

2. Processing and evaluation of agro-climate index of frost resistant species (Tiahara Unshiu, Adreula and Michurinetsi 2540), including selecting and revealing of optimal natural conditions (without accomplishing any agro action) (by creating a virtual sample model), scientific grounding of its

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cultivation and landscape zoning of territory, based on GIS – analyzes.

3. Morphological analysis (biometric index, starting-ending point of the first and second growth, starting-ending point of blossoming, starting of ripening and massive ripening, harvest, mechanical and biochemical composition of the fruit, tasting, storage properties, cost-effectiveness and frost (winter) resistance) of the tangerine – Tiahara Unshiu, introduced from Japan was accomplished.

4. For researching potential capabilities of specie adaptation and quality index of the fruit, sugar content was verified via Bertrand's method, vitamins via Murr method, total acidity – via titration method. Frost resistance of the plants was verified by frosting two years plants and cut branches in artificial climate laboratory, etc.

5. It is recommended to cultivate in the first citrus zone (total of active temperatures more than 40 000) of the west Georgia, the following tangerine species: broad-leaved Unshiu, Georgian "Saadreo", Tiahara Unshiu, Adreula and Michurinetsi 2540, and tangerine early ripe species (Georgian "Early Ripe" Saadreo, Tiahara Unshiu and "Adreula") are recommended to cultivate in the regions with less then 40 000 of total active temperatures in vegetation period, such regions include (zone II) – Chokhatauri, Senaki, Tsalenjikha, Zugdidi.

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