Dependence of quality indicators of tea leaves on soil metal ions

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Abstract. The article presents information on the influence of metal ions on the shoots of the Chinese tea plant - *Thea sinensis* L., cultivated in experimental and field conditions of the Lankaran Regional Scientific Center. The research was carried out in 2022-2023 on river sections located in the village of Khanbulan of Lankaran region, and the village of Khychu, Lerik region, which represent a subtropical zone with high humidity. Soil samples were taken and its water capacity and water-holding capacity, mechanical and organic components, as well as ions of certain metals were determined. The tea plant is very sensitive to environmental factors. Demanding on soil acidity, relative humidity, light and heat. Therefore, in our studies, to ensure the dynamic development of the tea plant, ash-yellow and ash-clay-yellow soil samples were taken. Thus, since the common soil types in this region are ash-clay-yellow and provide the presence of metal ions in the lump, this affects both the quality of the tea leaf and the antioxidant nature of the bioactive compounds of the extractive substance, as well as the color shades of tea. It is in this regard that the tea plant differs significantly from other drinks in its active influence on people's well-being and health. For this, flavonoids are used in tea leaves - theine, catechin + theine complex, flavanol, caffeine, etc. Quantitative indicators are defined as a quantitative change in the extractive substance depending on metal-ions [1, 2, 3]. It is clear from the research that a certain metal ion is dominant for tea plants according to the nature of soil types. For the tea plant, FeO, Fe2O3, Ał2O3, MnO (iron and aluminum ions) are of special importance and are indispensable nutrients.

1 Introduction

Food production is one of the global problems that humanity is facing. Plant products play an important role in supplying the human body with vitamins and are irreplaceable. That is why preference should be given to products of plant origin, productive, adapted to new climatic conditions and environmentally friendly. The creation of new varieties of food plants and ensuring their dynamic development has become an urgent problem, is one of the priorities and is of great importance. One of the products used in people's lives since ancient times is tea. Due to its nutritional value and biochemical properties, tea differs from other alcoholic drinks and does not have a harmful effect on the human body [4]. Tea is the second most popular non-alcoholic drink after water in the world, including our republic. It has a tonic effect on the human body. Therefore, people use tea as a means of relieving fatigue and general weakness of the body. The rich biochemical composition of tea confirms its physiological and biochemical value. The tea plant has been grown in the countries of the Far East, Japan and China for more than 2.5 thousand years. Its homeland is China, and its cultural form is cultivated in China to this day. Europeans became acquainted with the tea plant in the 18th century, and C. Linnaeus in 1753 named this plant after the Greek goddess Thea. There are currently 23 species of the tea family (*Theaceae*) and more than 30 species diversity. Tea is cultivated in China, Japan, Vietnam, Korea, Burma, etc. countries, and it gained fame in India and Sri Lanka [5].

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2 Materials and methods

New tea formations of Chinese tea variety (Thea sinensis L.) created in experimental and field conditions of Lankaran Regional Scientific Center located in Lankaran region were used in the research. The variety of Chinese tea (*Thea sinensis* L.), cultivated in the highly humid subtropical region of the Republic of Azerbaijan, is a short-stemmed shrub with a height of 3-5 m. By biometric measurements, the leaves are 6-8 cm (sometimes 5-7), large and medium, the surface of the leaves is smooth, the collection of anthocyanins during the development of the apical leaves draws attention to itself. The vegetation period of this variety in the subtropical regions of Azerbaijan is 180-210 days. While on the plain the growth is intensive in March-April, in the areas planted on the mountain slopes, in the early morning hours of sunlight, the growth of the shoots, "irritated" by the influence of ultraviolet rays, develops speedy in the second decade of April. On this site, the shape of the bushes is "full", and on the flat site - more vertical. From an ecological point of view, the Chinese variety develops optimally at a relative humidity of atmospheric air of 70-80%, indicators of the thermal factor of 28-32^{0}C, resistant to frost and temperatures (-14 and 15^{0}C). At soil acidity of 4.5-5.0 (pH), the physiological and biochemical indicators of the tea plant are high, and the quality indicators are much better. Yellow-ash and ash-clay-yellow soils with a depth of 30-35 cm were taken in the course of research on the river sections in the area of the village of Khanbulan of the Lankaran region and the village of Khychu of the Lerik region. Nitrogen (NO_3), potassium (K_2O), copper ($Cu^{+2}O$), magnesium (Mg^{+2}), sulfate ion ($SO4^{-2}$), calcium (CaO^{+}), free Cl_2, $Al_2^{+3}O_3$, $Fe_2^{+2}O_3$ and manganese (Mn^{+3}) from the soil, the mechanical, organic components and chemical composition of the soil were determined at the "Soil Science and Argo Chemistry institute" of the Ministry of Science and Education of the Republic of Azerbaijan and determined by the device "Palintest"-7100 soil and spectrophotometric method.

3 Results and discussions

Chinese tea variety (Thea sinensis L.) is a 3-5 m tall, short-stemmed shrub. According to their biometric size, the leaves are 6-8 cm (sometimes 5-7), large and medium-sized, smooth leaf surface, the collection of anthocyanins during the development of the tip leaves attracts attention. The vegetation period of this variety in the subtropical regions of Azerbaijan is 180-210 days. Since the tea plant is sensitive to environmental factors, fine-textured ash-yellow and ash-yellow-clay soils are considered more suitable to ensure its dynamic development. Soils with a predominant clay content are favorable for obtaining high-quality products. According to Prof. F. Guliyev, neutral soils with a high content of mechanical substances are unsuitable for the river [6, 7]. The highly humid subtropics of the Lankaran-Astara region of the Azerbaijan Republic, the abundance of water sources, and rich vegetation played a special role in the formation of soil types here. In the 20-25 years of the 20th century, many scientists paid attention to the soil structure of this place. The lands of both Lankaran and Astara-Lerik regions are changeable and diverse in a wide range. If ash-yellow soils predominate in the areas, then there are also many ash-yellow-clay soils. In most cases, ash soils are common in flat areas, and ash-yellow-clay soils are common on mountain slopes [2, 8]. Although the mentioned authors explain the humus layer, mechanical structure, water storage and

water capacity of ash-yellow or ash-yellow-clay soils, the chemical composition of the soil, the amount of organic and mineral micro- and macro elements in the soil around the roots. There is no information on the distribution of various ions in the soil. There is no information about metal ions in the physiological and biochemical processes of the tea plant. Depending on the metal ions, the role of biologically active compounds of tea leaves in the formation of extractive flavonoid compounds becomes of particular importance [9, 10, 11]. The article discusses environmental factors - temperature, water shortage, decrease in relative humidity, changes in soil components, etc. under climate change conditions. An interpretation is given of the influence of abiotic factors on the physiological and biochemical properties of the tea plant, the participation of metal ions in the metabolic process, and the effect on the quality and productivity of tea. The research used new tea and citrus plants and soil samples from the experimental territory of the LRSC in 2022-2023 from the new tea formation of new Chinese tea diversity. The results obtained are interpreted in comparison with data from studies conducted in the region. The results obtained are presented in tables. It is clear that the presence of an acidic environment is one of the main conditions for the optimal development of the tea plant. of the humid subtropical regions of our republic. In Lankaran-Astara region, where tea plants are grown; relative air humidity is 65 – 75%, pH of the soils is 4.5 - 5.5. At a soil depth of 0.65 - 100 cm, its root system develops optimally, and the formation of stems and leaves actively occurs. In this case, the biologically active compounds of the collected flashes are much higher. As noted in modern literature, flavonoids are biologically active compounds collected in the apical leaves of the tea plant from the first stage of development, and antioxidant substances formed as a result of reactions can influence stress factors that arise in the body and change the properties of structural elements cells [12, 13]. These antioxidant compounds are able to neutralize various free radicals, which are the cause of the most serious diseases in our modern world - diabetes, atherosclerosis, hypertension, Alzheimer's and Parkinson's diseases. To reduce the risk of developing these diseases, foods containing iron and copper ions should be used to reduce the number of free radicals in the diet. Among these products, tea is the most effective. Some reports claim that fermenting tea leaves can produce green, black, yellow, red and even white colors [14]. Schulze J. et al. note that biologically active compounds in the tea drink reduce the rate of division of malignant cancer cells [15]. By Chen S.K. and our opinion, it is possible to treat a neurodehydration property of brain cells as a result of exposure to biologically active compounds – tea polyphenols – in severe diseases such as Alzheimer’s and Parkinson’s diseases [16, 17]. The antioxidant properties of flavonoid compounds present in tea extract solutions prevent these processes [6-10]. Currently, along with the world's leading researchers, research scientists from our Republic are also working in this direction. In addition to the antibacterial properties of tea extract, they are also conducting serious research on the role of quality indicators of the tea plant in the exchange of metal ions in the soil, the formation of tea extract with different shades.

F.A. Gulyev, X.Y. Babayev, R.K. Huseynov R.K. they note that the soils of the Lankaran-Astara region are yellow-podzolic-clayey and vary from slightly acidic (PH 5.9-6.7) and (PH 5.1-5.7). The aqueous product of the soil is sometimes noted as PH 5.6-6.7. However, yellow-podzol soils vary between medium acidity level (PH 4.0-5.1). X. Y. According to Babayev (2017), the amount of humus in podzol-yellow soils is 1.5 t per 1 ha, and 1.7 t per 1 ha in podzol-clay-yellow soils (2017). Total nitrogen-0.10% in area 1, 0.11% per 1kg in area 2, total phosphorus (as P2O5) in the soil, respectively 0.10% and 0.12%, as potassium (K2O) 2.30% and 0.35% provided. According

to the author's material, the amount of Ca+2 and Mg+2 elements is 89.0 and 90.7; The amount of Al+3 was 1.06 and 1.07. However, since the unit of expression of the author's indicators is not mentioned, the indicators of metal ions are doubtful and it is impossible to agree. Because when the amount of Ca+2 ion is high, the amount of Mg+2 and Al+3 ions is more than nitrogen oxides. (Table 1.)

Table 1. Soil types, organic and mineral composition of Lankaran-Astara region

Organic and mineral composition of the soil	Soil types					
	Podzol-yellow			Podzol-gleyy-yellow		
	1994-2000	2012-2017	distinction	1994-2004	2012-2017	distinction
Hummus, in %	1,9	1,5	0,4	1,9	1,7	0,2
Total nitrogen, in %	0,13	0,10	0,03	0,12	0,11	0,01
Total phosphor, in %	0,13	0,10	0,03	0,15	0,12	0,03
Absorbed bases, mg/kg	23,10	21,0	2,1	23,68	21,80	1,88
$Ca^{2+} + Mg^{+2}$, in %	92,65	89,00	3,65	92,85	90,70	2,15
Al^{3+}, in %	1,03	1,06	0,03	1,03	1,07	0,04
$N/NH_3 + N/NO_3$, mg/kg	40,19	35,25	4,94	37,98	36,10	1,88
P_2O_5, mg/kg	144,89	150,30	5,41	126,81	123,40	3,41
PH aqueous solution	5,1	4,80	0,3	5,3	5,0	0,3
PH, salt solution	4,2	4,0	0,2	4,4	4,0	0,4
K_2O, mg/kg	122,80	25,60	2,8	136,41	140,0	3,59
Total potassium, in %	2,12	2,30	0,12	2,47	0,35	0,12

Kh. Y. Babayev presented (Table 1) of nitrogen compounds (NU3-N+NO3) in 1 kg of soil in 2017 was 35.2% in podzolic-yellow soils and 36.1% in podzolic-clayey-yellow soils, then the total amount of nitrogen in 1 kg of soil is is much higher than the indicator. The same opinion can be said about Al+3 ion, according to the author, the amount of ultramicro element is 10 times higher than nitrogen [2, 8]. The same point can be made about P2O5 and K2O. (Table 2)

Table 2. The amount of metal ions in the soils of Lankaran and Lerik regions, µg/g

Regions	Kind of soil	Metal ions							
		$Co^{+3}O_3$	$B_2{}^{+3}O_3$	$Mo^{+4}O$	$Cu^{+2}O$	$Fe_2{}^{+3}O_3$	$Zn^{+2}O$	Al_2O_3	$Mq^{+2}O$
Lankaran	Ash yellow	3,5	18,4	0,50	12,8	7,0	18,0	6,8	0,44
Lerik	Ash yellow clay	6,4	56,0	0,38	18,4	8,9	24,0	7,1	0,57

Note: The information is taken from the "Ecological Atlas" of the Republic of Azerbaijan, the amount of humus in Lankaran soil is 150-180 t/ha, and in Lerik region it is 200-250 t/ha.
Mineral chemical indicators of yellow-podzol and podgollu-glayy-yellow soils can be objectively evaluated according to the depth of soil types. Because the form and amount of mineral elements

decreases as you go to the deep layers of the soil (N, N2O5, NO3, K2O5, P2O5, MgO, CuO, etc.). The author calculated the amount of macroelements in the area of the root system as mg/eq per 100 g of soil mass. expressed as At this time, if we accept that the amount of absorbed nitrogen is 0.14 and 0.21%, it can be evaluated objectively [3]. (Table 3)

Table 3. The influence of metal ions in the soils of Lankaran and Lerik regions on some biochemical components of the tea plant, mcg per 10 g

Regions	Biologically active substances	Metal ions								
		$Cu^{+2}O^{-}$	$Fe_2^{+2}O_3^{-}$	ZnO^{-}	$Mq^{+2}O^{-}$	$Mn^{+2}O^{-}$	$Sn_2^{+3}O_3^{-}$	$Co^{+3}O^{-}$	$Al_2^{+3}O_3^{-}$	$Mo_2O_3^{-}$
Khanbulan of Lankaran (ash yellow soil)	Teine	21±0,4	18±0,1	22±0,1	23±0,9	24±0,2	21±0,4	22±0,1	12±0,4	10±0,2
	Catehine-teine	24±0,7	25±0,8	26±0,1	22±0,7	21±0,8	21±0,6	19±0,3	13±0,1	12±0,3
	Flavonol	17±0,1	18±0,6	19±0,5	21±0,2	20±0,3	18±0,3	21±0,9	16±0,3	13±0,8
	Caffeine	14±0,8	15±0,3	16±0,3	17±0,8	18,0,2	21±0,2	23±0,6	20±0,1	17±0,7
	Exstructive combinations	38±0,2	37±0,6	39±0,4	40±0,4	44±0,6	44±0,1	40±0,4	20±0,5	19±0,
Khychu, Lerik region (ash clay yellow soil)	Teine	20±0,3	24±0,4	22±0,1	24±0,2	25±0,3	21±0,5	22±0,3	20±0,6	14±0,5
	Catehine-teine	27±0,5	26±0,5	26±0,4	26±0,5	27±0,4	25±0,4	24±0,1	19±0,3	14±0,1
	Flavonol	19±0,1	21±0,1	22±0,3	24±0,3	25±0,5	26±0,1	24±0,2	21±0,5	16±0,3
	Caffeine	16±0,1	20±0,3	21±0,2	24±0,7	24±0,3	28±0,3	22±0,2	18±0,2	17±0,3
	Exstructive combinations	18±0,4	38±0,2	43±0,4	41±0,2	42±0,1	24±0,1	44±0,6	15±0,4	14±0,1

The potassium element ensures the permeability of the membrane of the cytoplasm of the plant cell. The entry of this element into the root system as K2O5 depends greatly on the type of soil. Thus, in podzol-yellow soils, its permeability (Na/K pump) ensures the optimal development of the root system and increases the absorption capacity of the root. Its active activity ensures the rapid growth of the root system of the tea plant, and under favorable

conditions, it varies in the amount of 50-60 mg/eq in the hydroturium formed around the root system. If the soil depth is less than 60 cm, the development of the tea plant is seriously weakened. 100 g of soil is taken up to 65-80% in spring and autumn, depending on the rainfall and irrigation rate, and in summer, 40-55% in plain areas. These indicators vary between 70-80% and 60-65% in podzol-clay-yellow soils, especially in mountainous areas. The water retention capacity of the soil also varies depending on the geographical location. It should be noted that the water retention capacity of podzol-clay-yellow soils is significantly different from podzol-clay-yellow soils, sometimes it is 10-20% higher than the indicator there. When the water content and water retention capacity of the soil is at an optimal level, the chemical structure of the soil and the metal ions formed there, the height and growth of the tea plant are indicators of productivity, but the activity of metal ions in the soil is the main quality criterion depending on the biological essence and activity of the metal ions. It is known that in the absence of Fe2 O3 in the soil, the photosynthesis process does not take place in the leaves, and the biochemical active substances in plant cells, especially tein, catechin, catechin + tein complex, flavonol, caffeine, glycosides, antistanes, etc., are among the main flavonoids that are the quality factor of tea. compounds cannot be synthesized. Iron ions in the soil ensure the development of the tea plant.

4 Conclusion

Chinese tea variety is demanding on the soil, organic components, chemical and mechanical structure of the soil, carbonate salts are a minority, PH indicator is relatively weakly acidic (PH-4.0-4.5), water retention and water content 70-75%, lighting and relative in soils with high humidity, it optimally continues the growth and development process. In Lankaran-Astara region - FeO; Fe2O3; CuO+2; MgO+2; Sn 2O3; MnO; CoO; ZnO+2; Al2O3- etc. when metal oxides are 20-25 mg/eq per 1 kg of soil, the quality indicators of new river formations, as well as extractive compounds (summary), are at an optimal level. It has been revealed from the conducted researches and rich literature sources that the importance of antioxidant flavonoids in tea leaves due to the effect of metal ions has not been widely covered. Only in the researched source, as well as its authors F.A. Guliyev, H.H. Asadov. and Sadygova K.A. have widely illuminated the biochemical nature of metal ions in the soil, the quality indicators and color shades of tea products in the Republic of Azerbaijan have been investigated for two times. It was clear from the researches that according to the nature of soil types, a certain metal ion is dominant for both tea plants. Thus, FeO, Fe2O3, Al2O3, MnO ions of iron ions are of special importance for the tea plant. Iron and aluminum ions are indispensable nutrients for the tea plant.

Since the types of soils common in the Lankaran-Astara region - podzolic - clayey - yellow and ensure the presence of metal ions in the lump, it affects both the quality of tea leaves and the antioxidant nature of biologically active compounds of the extractive substance (summary), as well as the color shades of tea. In this regard, the tea plant differs greatly from other beverages in terms of its active effect on people's sense of health and well-being.

Authors' contribution

Methodology, Investigation, Resources, Huseynaga Asadov; Minara Gasanova; Kamala Sadigova; Writing – Review & Editing, Kamala Sadigova; Original Draft Preparation, Huseynaga Asadov; Project Administration, Idris Khojatov; Funding Acquisition, Mardan Shiraliev.

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