# The influence of growth regulators on the tea quality in the foothill zone of the North-West Caucasus

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**Abstract.** Agroecological assessment of the natural resources of the Adygea allowed to identify the main factors limiting the productivity of tea plants. Such factors determine a low yield and tea quality within the zone. Tea refers as a food product; therefore, to activate productivity and improve quality indicators on plantations, it is possible to use eco-friendly cultivation technologies only, for example, processing with growth regulators, which are used in organic farming. The content of ascorbic acid, extractives and tannin in 3-leaf tea flushes was determined. The treatments with growth regulators activate the accumulation of ascorbic acid by 1.5 - 1.8 times compared to the control option (116.8 mg/g of raw mass). Moreover, the largest amount of ascorbate is synthesized in flushes treated with rokohumin (177.8 mg/g) and bombardier (207.9 mg/g). Studies have shown that when treated with growth regulators, there is a slight increase in the amount of extractives (32.1-34.9 %, in the control – 31.3 %) and tannins (21.7 % – 22.9 %, 20.4 % in the control). The calculation of the smallest significant difference showed the presence of significant differences between the experimental options and the control for all the analysed characteristics.

## 1 Introduction

The tea plant is a unique biological species; its main growth limiting factors include the temperature regime and the total amount of precipitation, which generally determined the natural growth area of this plant. In the conditions of the Black Sea coast of Russia, as well as in a number of other regions of the world (China, India, Japan), this perennial plant faces a number of external stress factors (cold, solar insolation, hyperthermia, drought, mineral insufficiency) under the influence of which its productivity decreases. In horticulture, various agrochemicals are widely used to increase the productivity of plantings. One of the directions is the use of phytohormones, which are physiologically active substances. According to several authors [1-11], they can be used to increase the productive sets' formation, which is especially important in adverse weather conditions during periods of generative buds' differentiation and flowering.

In the Republic of Adygea, the tea-growing industry intensification is possible only if conditions are created that meet the requirements of culture, in which the genetically

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inherent productivity potential would be revealed. Agroecological assessment of the region's natural resources revealed the main factors limiting the productivity of tea plants: low air temperatures in winter and early spring periods, insufficient moisture supply combined with high temperature and atmospheric drought in the summer months. This is the reason for the low yield of 20 ± 5 cwt/ha in the zone [12-14]. At the same time, as shown by the studies of domestic and foreign scientists, increasing plant immunity, frost resistance, and drought resistance of crops is possible through the use of plant growth regulators, which are physiologically active substances [1, 5, 6, 10]. Since tea refers to food products, particularly beverages widely consumed by different age groups of the population, it is important to use eco-friendly technologies for cultivating tea plantations on plantations; those include the use of growth regulators used in organic farming.

## 2 Objects and methods of research

Research has been conducted since 2019 on the basis of the Adygea branch of the Federal Research Center "Subtropical Scientific Center of the Russian Academy of Sciences" (FRC SSC RAS). The plantation (6 ha) is located at an altitude of 540 m above sea level on the North-western slope of the Caucasian ridge; it is planted with seeds of Chinese tea plants. The soils of the experimental site are brown forest. Fertilizers are applied annually: before the growing season start (April) – 60% nitrogen, 100% phosphorus and potassium (N250P100K100 kg/ha a.c.); fertilizing with ammonium nitrate (40% nitrogen) is carried out in June.

### 2.1 Objects of research

The objects of research were tea plants of the Kimyn variety population.

The following preparations were used as plant growth regulators: rokohumin (5 ml / 10 liters of water); sodium humate (1.5 g / 10 liters of water) and bombardier (20 ml / 10 liters of water). Rokohumin (manufactured by "ROKOSAN" LLC, the Slovak Republic) is a liquid organomineral fertilizer based on humic, fulvic acids and trace elements. Bombardier biostimulator (manufactured by Kimitec, Spain) contains a complex of free amino acids, fulvic acids, and natural biostimulators (betaine, auxin, vitamins, enzymes, carbohydrates). Sodium humate is a natural growth stimulant containing humic and fulvic acids (produced by Chebarkulskaya Ptitsa LLC, Russia). Control (plants' treatment with water). The size of the experimental plots was 9 m2, the field experiment repetition - threefold. Top-dressing treatments were carried out three times: at the beginning of the growing season after pruning tea plants (the second decade of May); after the second growth wave (the first decade of July); in the second decade of November in preparation for the winter dormancy period.

Phenological observations were carried out under the conditions of field experiment; growth activity was determined (average height and average diameter of tea bushes; annual growth). The weather conditions analysis of the growing season and the research period was carried out according to the data at www.pogodaklimat.ru

### 2.2 Research methods

Laboratory studies were carried out in the laboratory of Plant Physiology and biochemistry of the Center and on the basis of the Adygea branch of the FRC SSC RAS. The repeatability of laboratory tests - threefold.

The determination of extractives in flushes was carried out by weight method according to GOST R ISO 9768-2011 (Tea. Determination method of water-soluble extractives), based on the method by V.E. Vorontsov [15], tannin – as per Levental with a conversion coefficient of 5.82 (according to K.M. Dzhemukhadze) [16]. The method is based on tannin oxidation by potassium permanganate when using indigo carmine as an indicator. Dry matter was determined by the weight method according to Chupakhina [17]. Ascorbic acid (AA) was determined by the classic iodometric method [17], potassium iodate solution served as the titrant. Titration was carried out in the presence of potassium iodide and hydrochloric acid (starch as indicator) until persistent blue staining.

To check the correlation significance and estimate statistical values, an analysis was performed using the ANOVA package in STATGRAPHICS Centurion XV (version 15.1.02, StatPoint Technologies) and MS Excel 2007. Statistical analysis included one-dimensional variance analysis (method of comparing averages using analysis of variance, t-test). The difference significance between the mean values at $p < 0.05$ was considered statistically significant.

## 3 Results and discussion

Tea plantations located in the Adygea branch of the FRC SSC RAS are the northernmost not only in Russia, but also in the world. In general, the soils and climate of the middle sub-zone of the foothills of Adygea (from 450 m to a height of 1000 m above sea level) allow growing tea plants [12, 14]. The foothill zone is characterized by a relatively harsh climate. According to long-term data, the absolute minimum is observed in January and is -33.7 ° C; the absolute maximum is 39.8 ° C (in August). Tea plants' stress factors include recurrent spring frosts and a dry period lasting from the third decade of July to the third decade of August [13, 14]. Growing in such difficult conditions, tea plants show high adaptive potential [18].

The research has shown that tea plant treatments improve the plants' functional state (activate protective mechanisms) [19], as well as affect the qualitative composition of flushes (Table 1).

Extractives are the sum of all compounds soluble in hot water; they are also one of the important quality indicators of both the green leaf and the finished product. The specific astringent, pleasantly bitter taste of the drink and the reddish color of the tea infusion depend on the extractives. It is known that the extractives' content is also used to determine the tea grade during its physico-chemical studies. In turn, tanning agents are a mixture of various polyphenols, but the main tanning agent of tea is tannin. Tannins are the most mobile and active substances, so they vary greatly under different growing conditions.

As can be seen from the data in the table, there is a significant increase in tannins and extractives in all options with treatment. Moreover, a significantly larger amount of extractives is synthesized by plants on options with top-dressing bombardier treatment. At the same time, tannins accumulate significantly more in treatment with humate and rokohumin.

**Table 1.** Chemical composition of 3-leaf tea flush, 2019-2021

| Option | Dry matter, % | Extractives, % | Tannins, % |
|---|---|---|---|
| Control | 36.0 ±4.27 | 31.3 ±5.37 | 20.4 ±2.63 |
| Sodium Humate | 38.3 ±3.59 | 32.1 ±4.79 | 22.9 ±3.69 |
| Rokohumin | 41.3 ±3.21 | 32.5 ±4.77 | 22.4 ±4.44 |
| Bombardier | 39.4 ±3.57 | 34.9 ±5.52 | 21.7 ±4.93 |

| | | | |
|---|---|---|---|
| ***LSD05*** | ***1.96*** | ***2.75*** | ***2.33*** |

Due to that the beverage's formation of the taste and aroma, the biological value of tea, and its grade is determined by the content of tannin and extractives, the increased synthesis of these compounds under the influence of growth regulators is a positive aspect.

In addition to tannin and extractives, the content of ascorbic acid (AA, vitamin C), which is a natural antioxidant, is important for the nutritional significance of tea. The studies have shown that significantly higher amounts of vitamin C are characteristic of options with bombardier treatment (207.9 mg/100 g of raw mass) and rokohumin (183.2 mg/100 g), which is 1.5-1.7 times higher than the control (Fig. 1).

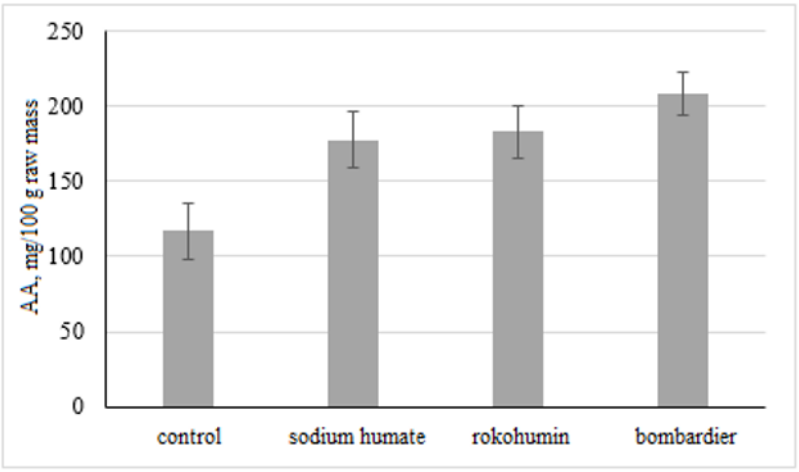


**Fig. 1.** Ascorbic acid content in 3-leaf flushes (LSD05 = 19.87), 2019-2021

However, to assess the effect of growth regulators on tea plants, it is not enough to know the qualitative composition of raw materials; for tea, the mechanical composition of the harvested crop is also important – the number of flushes, their grade (fully developed 3-leaf shoots or dormant buds – shoots that stopped growing due to stress), the growth of flushes, etc. Studies have revealed the influence of regulatory fertilizers on the main indicators that determine the productivity of tea plants (Fig. 2). It was found that a greater number of flushes are laid when treating the plants with sodium humate (195.0 pcs. with 140.7 pcs. under control); however, it inhibits their growth (the increase during the growing season was about 13 cm). In this regard, treatments with rokohumin are preferable, since the optimal ratio between the number of setting flushes (160.7 pcs.) and their growth processes (15.4 cm per vegetation) is maintained. This leads to a significantly higher yield in this option – 22.73 cwt/ha with 19.77 cwt/ha in the control (LSD05 = 5.20).

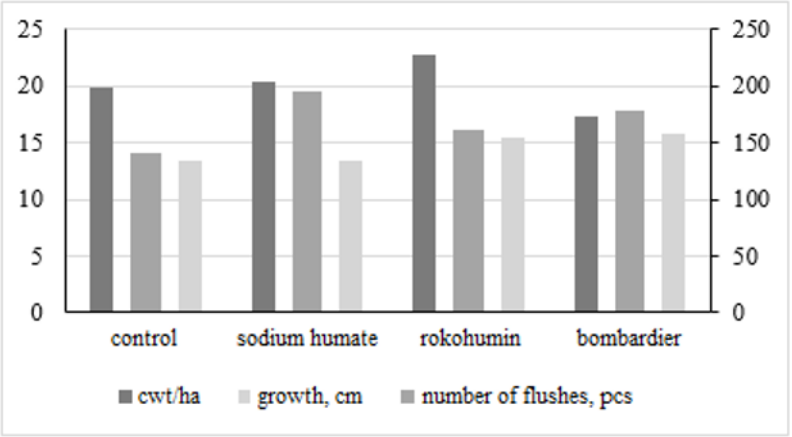


**Fig. 2.** Productivity of tea plants, 2019-2021

Thus, the effect of growth regulators on quality indicators, growth processes and yield of tea plants was shown. These studies were aimed at activating the mechanism of plant resistance to abiotic stressors of the foothill zone of the Northwest Caucasus when using growth regulators on tea plantations; substantiating the prospects of their use to increase plant productivity and product quality.

## References

1. V.S. Shevelukha, I.K. Blinovsky *The state and prospects of research and application of phytoregulators in crop production* (Growth regulators, M., 1990)
2. V.A. Gudkovsky *Scientific foundations of sustainable horticulture in Russia,* in Proceedings of the International conference Stocky horticulture, Michurinsk, Russia (1999)
3. Wajahatullah Khan, Usha Menon, Sowmyalakshmi Subramanian, Mundaya N. Jithesh, Journal of Plant Growth Regulation **28(4),** 386-399 (2009)
4. T.N. Doroshenko, S.S. Chumakov, D.A. Majar, S.S. Chukuridi, M.D. Omarov, T.A. Kopnina Proceedings of the Kuban State Agrarian University **1(46),** 56-61 (2014)
5. E. Tacken, Plant Cell Physiology **55(5),** 1005-1016 (2014)
6. T.N. Doroshenko, L.G. Ryazanova, A.M. Abdul-Mir Al-Husseini, D.V. Maksimtsov, N.I. Nenko, O.G. Belous Proceedings of the Kuban State Agrarian University **1(64),** 71-77 (2017)
7. A.V. Ryndin, O.G. Belous, V.M. Gorshkov, T.N. Doroshenko, L.G. Ryazanova A.M. Abdul-Mir Al-Husseini, Fruit and berry growing in Russia **51**, 92-99 (2017)
8. A.V. Ryndin, O. G. Belous, M. D. Omarov, Yu. S. Abilfazova Problems of ecology and agrochemistry **3,** 34-38 (2019)
9. A.G. Lagoshina, E.K. Pchikhachev, O.G. Belous Horticulture and viticulture **3,** 23-28 (2021)
10. A.G. Lagoshina, E.K. Pchikhachev, O.G. Belous Subtropical and ornamental gardening **78,** 119-129 (2021)
11. O. Belous, M. Vasileiko, A. Lagoshina, N. Platonova, E3S Web Conf. **254,** 1-6 (2021)
12. A.V. Ryndin, E.K. Pchikhachev *History, current state, and prospects of development of tea growing in the Republic of Adygea,* in Proceedings of the International

conference Current state and prospects of development of horticulture and tea culture in the Republic of Adygea, Maykop, Republic of Adygea, Russia (2008)

13. B.V. Korzun, L.V. Vavilova, Subtropical and ornamental gardening **43(1)**, 13-18 (2010)
14. S.V. Dobezhina *Study of agroecological features of tea culture in the conditions of Adygea for the development of innovative cultivation technology* (Innovative processes in science and education, Penza: MCNS Nauka and Prosveshenie, 2017)
15. V.E. Vorontsov Biochemistry of tea (Moscow: Pishchepromizdat, 1946)
16. K.M. Dzhemukhadze *The physiology of tea.* In the book: Physiology of agricultural plants (Moscow: MSU TECH, 1970)
17. G.N. Chupakhina Physiological and biochemical methods of plant analysis: Workshop (Kaliningr. un-ty, Kaliningrad, 2000)
18. T.V. Pshenichnaya, Subtropical and ornamental gardening **44,** 130-134 (2011)
19. O.G. Belous, N.B. Platonova, Natural and technical sciences **10,** 41-44 (2019)