

The Effect of Chlorella Growth Stimulant on Maize Development in Southern Kyrgyzstan

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Abstract. Biostimulants are increasingly used in agriculture. They can boost plant productivity, improve crop quality, and reduce dependence on chemical pesticides. Plant growth biostimulants are products that enhance natural physiological processes in plants.

This article presents the results of a study on the effect of a growth biostimulant based on the microalga *Chlorella vulgaris* on the growth and development of corn (*Zea mays* L.) in the Bazar-Korgon district of the Jalal-Abad Region, Kyrgyz Republic. The aim of the study was to evaluate the effectiveness of using a chlorella suspension in comparison with traditional organic (biohumus) and mineral (NPK) fertilizers. Field experiments were conducted in 2023–2024 on the PIONEER PR31G98 corn hybrid. *Chlorella* was applied via three foliar sprayings of the plants at the 2–3, 4–6, and 8–10 leaf stages. The impact was assessed based on key morphometric indicators: plant height, leaf blade parameters, stem diameter, leaf mass, and root system development.

The results showed that treating plants with a *Chlorella vulgaris* suspension resulted in a statistically significant increase in all studied parameters compared to the control and treatments with vermicompost and mineral fertilizers. The most pronounced effect was observed in the development of the foliage and root system, indicating a complex and prolonged biostimulating effect of chlorella.

Key words: biostimulant, chlorella suspension, microalgae, humus, fertilizers, soil, corn, hybrid, plant parameters, agriculture.

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Introduction

In the context of global population growth, addressing issues of resource scarcity and environmental protection takes on particular importance. To achieve sustainable development, it is necessary to implement innovative and effective systems, particularly in the agricultural sector, which will help strike a balance between the needs of the population and the conservation of natural resources. This approach promotes the development of environmentally responsible farming practices, improves resource efficiency, and reduces negative environmental impacts, which is a key aspect of the long-term sustainability of the global ecosystem. The use of microalgae and vermicompost as biostimulants and biofertilizers in modern agriculture is well documented, as they promote plant growth and nutrition, reduce the need for chemical fertilizers, and improve soil health (Coppens et al., 2016; Renuka et al., 2016, 2018). Renuka et al. (2018).

Biostimulants are increasingly used in agriculture. They can increase plant productivity,

improve crop quality, and reduce dependence on chemical pesticides. Plant growth biostimulants are preparations that enhance natural physiological processes in plants.

The green algae *Chlorella vulgaris* stimulates plant growth by producing growth hormones, vitamins, macronutrients (N, P, K), and micronutrients (Fe). [Bajguz and Piotrowska-Niczyporuk, 2013]. *Chlorella* sp. improves soil structure and aeration and absorbs heavy metals. Growth stimulants and organic fertilizers based on green algae are widely used in countries such as Hungary, India, Egypt, Portugal, the Scandinavian countries, as well as in Ukraine, Russia, and Uzbekistan. In Kyrgyzstan, the use of chlorella remains relatively unknown, creating potential for expanding its application in the agricultural sector. These innovative agricultural technologies contribute to increased crop yields, improved soil quality, and sustainable agricultural development. The adoption of such methods reduces the use of chemical fertilizers and promotes environmental safety. Overall, the use of green algae as biostimulants and organic fertilizers is

a promising area that can significantly increase the efficiency of agricultural production in various regions of the world, including countries with developing agricultural infrastructure, such as Kyrgyzstan.

Chlorella vulgaris can be successfully used either on its own or in combination with various rhizobacteria, which enhances its biological activity and efficacy in various applications, including agriculture and medicine [Raposo and De Moraes, 2011; Gonzales and Bashan, 2000].

Plant growth and development depend on a variety of factors, including genetic characteristics, environmental conditions, and the availability of growth stimulants. The use of natural biostimulants is becoming increasingly important in the context of sustainable agriculture. *Chlorella*, thanks to its rich composition, is gaining attention as an environmentally friendly plant growth stimulant.

The objective of this study was to investigate the effect of a *Chlorella vulgaris* growth stimulant on the growth and development parameters of corn under conditions in the Jalal-Abad region.

Research Methodology

Field studies were conducted in 2023–2024 at an experimental plot located in the village of Seyt-Kazy, Bazar-Korgon District, Jalal-Abad Region. The aim of the experiment was to evaluate the effect of a growth biostimulant based on the microalgae *Chlorella vulgaris* on the growth and development of corn plants in comparison with traditional fertilization systems.

Brief Description of *Chlorella vulgaris*. *Chlorella* (*Chlorella*) belongs to the phylum Chlorophyta, the order Chlorococcales, and the family Chlorellaceae. *Chlorella* is a group of autotrophic protococcal green algae, primarily consisting of single cells that are spherical in shape and range in size from 2 to 10 micrometers. This single-celled green microalga has a high content of biologically active substances. It is considered one of the oldest life forms on our planet, with an existence spanning more than three billion years.

In recent years, *chlorella* has increasingly been regarded as a promising plant growth biostimulant.



Fig. 1. *Chlorella* viewed under a microscope

Fig. 2. *Chlorella* suspension

Composition of *chlorella*:

- chlorophyll (up to 5% of dry weight);
- proteins (up to 60%);
- amino acids, including essential ones;
- vitamins B, C, E;
- phytohormones (auxins, gibberellins);
- micro- and macroelements (Mg, Fe, K, Ca, Zn).

This composition gives *chlorella* the ability not only to stimulate growth, but also to strengthen plant immunity and increase their resistance to stress.

In plant cultivation, *chlorella* is used:

- in the form of aqueous solutions for spraying leaves;
- as a soil amendment and for drip irrigation;
- for seed treatment before planting.

The object of the study were Pioneer PR31G98 hybrid corn plants. **Biological characteristics** of Pioneer PR31G98. PIONEER PR31G98 corn seeds are a mid-late ripening, high-yielding hybrid (FAO 700). The distinctive features of this hybrid are most fully realized in the southern regions, where the crop formation period is longer. The plant is very tall - 250-270 cm. It has a good grain yield, high starch and protein content. It is resistant to lodging, main diseases, and drought-resistant. Maturation is medium-late, uniform, and grain moisture content is high. Yield: high. Seeding rate: 50,000 to 75,000 seeds per hectare; days to biological maturity: 135 days.

Description of the methodology. The experiment was conducted according to standard field trial procedures with four replicates. Cultivation practices followed regional recommendations for southern Kyrgyzstan. Seeding took place on April 4 at a seeding rate of 20 kg/ha (56,000 seeds per hectare).

During the growing season, one cultivation, five irrigations, and two manual weeding were performed. The *Chlorella vulgaris* growth biostimulant was applied as an aqueous suspension via foliar spraying at a rate of 20 L/ha. Spraying was performed three times:

- in the phase of 2–3 leaves (April 14),
- in the phase of 4–6 leaves (April 24),
- in the phase of 8–10 leaves (May 15),

at intervals of 10–20 days.

To compare the effectiveness of *chlorella*, the following options were included in the experiment:

- control—no fertilizers or treatments applied;
- treatment with a *Chlorella vulgaris* suspension;
- application of organic fertilizer (vermicompost) at a rate of 5 t/ha;
- application of mineral fertilizer (urea) at a rate of 280 kg/ha.

Samples of plant material were collected 20 days after the second treatment and 17 days after the third treatment. During the study, the following key morphobiometric parameters were measured: plant height, leaf blade length and width, stem diameter, fresh leaf weight, and root system length and width. Yields were recorded on August 11. The data obtained were averaged over the two years of the study.

Results and discussion

The results presented in Table 1 indicate that the *Chlorella vulgaris* suspension has a significant stimulating effect on the growth and development of maize plants compared to the control treatment, as well as to treatments involving organic and mineral fertilizers.

Table 1. Results of data after the 2nd and 3rd treatment with *Chlorella vulgaris* suspension in the corn growth phase of 4-6 and 8-10 leaves on the studied plant growth parameters* in comparison with other experimental variants.

Options	Plant height, cm		sheet length, cm		sheet width, cm		stem diameter, cm		leaf weight, grams		Root system length, cm	Root system width, cm
	4-6 leaf phase	8-10 leaf phase	4-6 leaf phase	8-10 leaf phase	4-6 leaf phase	8-10 leaf phase	4-6 leaf phase	8-10 leaf phase	4-6 leaf phase	8-10 leaf phase		
Control	109	132	72.3	81.3	6.6	6.9	1.8	2.1	1.1	1.4	8.5	12
Chlorella	177	219	85.4	86.7	6.1	6.8	2.4	2.7	1.9	2.1	14	16
% increase	62	66	18	7	3	3	31	25	65	50	65	33
Biohumus	145.4	222	81	86.6	7.1	8.2	2.6	2.7	1.8	2.1	12	17
% increase	33	68	12	7	18	23	43	27	63	50	41	42

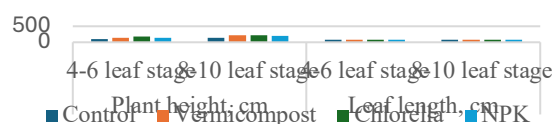
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NPK	137	194	80	84.14	6.63	7.38	2.25	2.46	1.73	2.0	12.315	15
% increase	26	47	11	4	11	10	22	13	50	43	41	25

* Plant growth parameters: stem height (cm), leaf length (cm), leaf width (cm), fresh leaf weight (grams), root system length (cm).

As early as the 4–6-leaf stage, a significant increase in plant height was observed following treatment with chlorella—62% higher than the control. At the 8–10-leaf stage, this indicator increased by 66%, indicating a prolonged effect of the biostimulant. In terms of this parameter, the chlorella treatment outperformed both vermicompost and mineral fertilizer, demonstrating the high physiological activity of the microalgae.

An analysis of leaf development showed that the application of chlorella contributed to an 18% increase in leaf length during the 4–6 leaf stage and a 7% increase during the 8–10 leaf stage. Leaf width also increased, although the differences were less pronounced, which may be due to the genetic characteristics of the corn hybrid. A significant increase in leaf mass (by 65% and 50%, respectively) indicates enhanced photosynthesis and organic matter accumulation (please see Diagram 1).

Diagram 1. The effect of chlorella on maize development compared to other experimental variants



The *Chlorella* variant *vulgaris* demonstrated a 65% increase in root length compared to the control, as well as a 33% increase in root width. These results are comparable to or superior to those obtained with vermicompost and mineral fertilizers. A well-developed root system ensures more efficient absorption of moisture and nutrients, which is particularly important under conditions of periodic moisture deficiency.

Diagram 2. Effect of chlorella on corn growth parameters compared to other experimental variants



The diagram (Fig. 2) clearly demonstrates the superiority of the chlorella treatment in terms of root system development. It was found that the roots of plants treated with the microalgae suspension were more branched and had greater overall mass, confirming the biostimulating effect of the product. Thus, the results obtained indicate that *Chlorella vulgaris*, as a biostimulant, has a comprehensive positive effect on the formation of above-ground and below-ground biomass in agricultural crops, promoting more balanced and harmonious plant growth compared to traditional fertilization methods.

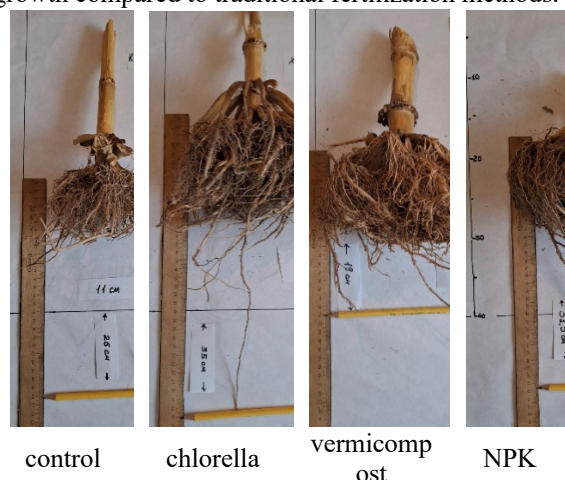


Fig. 3. Effect of chlorella on the development of the maize root system compared to other treatments



Fig. 4. Measurement of the parameters of the vegetative parts of corn by treatment.

The observed changes can be attributed to the high content of biologically active substances in chlorella, including auxin-like compounds, amino acids, vitamins, and trace elements, which help stimulate cell division and cell elongation, as well as enhance the photosynthetic activity of plants. The highest yield of raw cotton was recorded in studies conducted by Dr. Sh. Kh. Abdualimov, Ph.D. in Agricultural Sciences, [2023] in the Tashkent Region of the Republic of Uzbekistan, using the organic *Chlorella* preparation at a rate of 20.0–20.0–20.0 L/ha, with a yield increase of 5.5 cwt/ha, or 12.3% higher than the control. Similar results were obtained in studies by other authors, which showed that the fresh

weight of lettuce increased by 56.34% after foliar application of *Chlorella vulgaris*. The stimulating effect of algae as a biofertilizer on certain growth parameters of lettuce is also consistent with the results obtained by Rani and Satiamurti [1997]. Mahmoud and Amara [2000] found that all treatments significantly increased plant growth parameters compared to untreated plants. The significant increase in growth parameters recorded in this study is consistent with the work of many authors worldwide. Fahid and Abd-El-Fattah [2008] studied the effect of green algae on growth parameters and certain physiological responses related to the germination and growth of lettuce seeds (*Lactuca sativa*).

Conclusions

- The application of the *Chlorella vulgaris* growth biostimulant has a marked positive effect on the growth and development of corn plants at all stages of the growing season.
- Treatment with a chlorella suspension contributes to a significant increase in plant height, leaf development, and biomass accumulation compared to the control.
- The most pronounced effect was observed in root system development, which enhances the plants' adaptive potential and improves nutrient uptake.
- According to a number of indicators, the effectiveness of chlorella is comparable to or exceeds that of organic and mineral fertilizers.
- The use of *Chlorella vulgaris* is a promising and environmentally safe component of agricultural technologies aimed at increasing corn productivity.

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Conflict of Interest

None.

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