Increasing the toxic effects of fluorine compounds of winter wheat plant with the help of bacteria

Bakhron Boynazarov[1,*], *Gulnora* Djumaniyazova[2], *Tolib* Berdiyev[3], *Avaz* Islamov[1] and *Foziljon* Abdullayev[1]

[1]Tashkent State Agrarian University, 2, University street, Tashkent, 100140, Uzbekistan
[2]Tashkent State Technical University, 2, University street, Tashkent, 100095, Uzbekistan
[3]Research Institute of Soil Science and Agrochemistry, 3, Qamarniso street, Tashkent, 100179, Uzbekistan

Abstract. Wheat stands as a prominent cereal crop, holding significant importance in both food and production realms. In the cultivation of winter wheat within soil environments tainted with fluorine compounds, the application of mineral and biological fertilizers becomes imperative. This amalgamation of beneficial bacteria, coupled with growth-stimulating properties, plays a pivotal role in averting the uptake of toxic substances by plants. The article delves into experimental findings that shed light on the efficacy of TERIA-S bacterial fertilizer in diminishing the fluorine content across various components of wheat plants. These components encompass roots, leaves, stems, and grains. The research focuses on wheat cultivated in soil regions afflicted by fluoride contamination within the Surkhandarya region of Uzbekistan. Through systematic experimentation, the study highlights the capacity of TERIA-S bacterial fertilizer to mitigate the presence of fluorine in wheat plants grown within fluoride-laden soil conditions. This outcome bears significant implications for improving the quality and safety of wheat crops in regions plagued by fluorine contamination. By elucidating the potential of microbial interventions in addressing this ecological challenge, the research contributes to the arsenal of strategies aimed at safeguarding agricultural productivity and human health.

Keywords. Soil, fluorine compounds, TERIA-S bacterial fertilizer, wheat plants, enzymes, active oxygen,

1 Introduction

One of the environmental pollutants, fluorine is naturally present in rocks, coal, clay and soil and is the 13th most abundant element in the earth's crust [1]. Fluorides enter the biosphere through volcanic eruptions, coal-fired power plants, aluminum smelters, phosphorous fertilizer plants, and glass, brick, tile, and plastic factories [2, 3]. Fluorine exists in the environment mainly as hydrogen fluoride, metal fluorides and fluorine gas.

* Corresponding author: bakhron_boynazarov1001@mail.ru

Fluoride is a colorless gas formed by the reaction of fluorine with hydrogen and readily dissolves in water to form the corresponding acid [4].

Although a number of scientists have described the harmful effects of fluorine compounds on humans, plants and animals in their studies [5-8], no information has been provided on the positive effects of this element. Fluoride can reduce crop yields by up to 50 percent because most plants are extremely sensitive to fluoride. Harmful effects of fluorine compounds are high on cereal crops, especially wheat [9, 10]. Fluorine is a strong oxidant that causes oxidative changes in plant cells. This can increase the amount of ROS and inhibit the activity of antioxidant enzymes [11].

Biological fertilizers play an important role in improving the quality and productivity of agricultural products, because even in small concentrations they are able to increase plant growth and development, resistance to toxic effects [12]. A high amount of fluorine in the soil slows down the development of soil microorganisms, inhibits its enzymatic activity, disrupts the nitrogen regime and reduces soil fertility. It is desirable to use soil and rhizosphere bacteria when growing plants in soil contaminated with fluoride. The positive effect of rhizobacteria is manifested in the increase of plant productivity, their resistance to drought and the increase of phosphorus [13].

Banerjee et al. [14] isolated strains of *Bacillus* sp. that were resistant to 1500 mg L-1 fluoride and helped to reduce its levels in plants. These studies make it possible to introduce bioremediation techniques that reduce the harmful effects of fluorides [14].

Taking into account the above, the purpose of the research is to test TERIA-S bacterial fertilizer in order to reduce the poisoning of irrigated land with fluorine compounds and increase its resistance to harmful effects, and to develop an agrobiotechnology that will reduce the harmful effects of fluorine compounds in the cultivation of winter wheat.

2 Materials and methods

Agrochemical test experiments in Surkhandarya region of Uzbekistan adjacent to TajAK: (1) weakly infected soil (Shorchi district, Surkhandarya region, 75 km); (2) moderately damaged soil (Surkhandarya region, Denov district, 50 km); and, (3) conducted in agricultural production fields with heavily contaminated soil (Saraasia District, Surkhandarya Region, 15 km). In the experiments, 3 types of soil contaminated with fluoride were used.

Field trials were conducted under typical gray soil conditions under newly irrigated conditions, with 3 returns. The area size of each experimental unit was (20 m × 4.8 m) = 96 m^2, the total area of the experiment was 1440 m^2.

Laboratory experiments were conducted with bacteria and 5 liquid samples containing fluorine at different concentrations in order to study the ability of bacteria isolated in laboratory experiments to grow in an environment with fluorine added. Laboratory experiments were carried out according to the methods of setting up laboratory experiments in plants [15].

3 Results and discussion

Soil samples were taken from the 0-10, 10-20 and 30-40 cm layers of the Surkhandarya region of Uzbekistan, 16, 35, 50, 75 and 100 km away from the TajAK industrial plant. Chemical analyzes were carried out from the obtained samples in the appropriate order.

According to the obtained results, in the soils of the Sufiyan massif of Sariosiyo district, 16 km away from the source, easily soluble fluorine in the 0-10 cm layer increased by 24.8 mg/kg in spring and 26.0 mg/kg in autumn, the same situation in 10-25 cm and 25- 20.5 -

21.7 mg/kg proportionally in 50 cm layers; It was found to be 15.5-15.3 mg/kg. These indicators were found to be 1.5-2.6 times higher than the authorized standard (AS - 10 mg/kg) for the soils of this area.

It was noted that in the area of Uzun district (16 km from the source), where typical gray soils, which were irrigated in the past, are at a high level (2.5-3.5 times AS) with easily soluble fluoride in water.

It was found in the analyzes that in the 0-25 cm layers of soils in Uzun district and Denov district located 35 and 50 km away from the polluting source, water-soluble fluorine is 2.0-2.9 times higher than the permissible limit in autumn (Table 1).

Table 1. Amount of fluorine in soils at different distances from the polluting source in Surkhandarya region of Uzbekistan, mg/kg.

An object, an array	**Sample time taken**	**0-10 cm**	**10-25 cm**	**25-50 cm**
16 km from the source (Sariosiyo district)	Spring	24.8	20.5	15.5
	Autumn	26.0	21.7	15.3
35 km from the source (Uzun district)	Spring	22.3	20.6	15.0
	Kuzgi	26.3	29.2	23.5
50 km from the source (Denov district)	Bahorgi	16.8	11.6	14.0
	Kuzgi	22.4	20.1	15.4
75 km from the source (Shorchi district)	Bahorgi	10.5	8.1	9.3
	Autumn	13.3	11.6	9.6
100 km from the source (Kumkurgan district)	Bakhorgi	10.7	6.9	3.1
	Autumn	10.6	7.8	4.0
Standard	**10 mg/kg**			

In the 0-50 cm layers of the soils of Shorchi District and Kumkurgan District, which are 75, 100 km away from the polluting source, it can be seen that easily water-soluble fluorine is not much higher than the permissible norm or within the norm. Fluoride, which is easily soluble in water, can be transferred to cultivated agricultural crops and thus produce damage. Fluoride in soil enters bacteria mainly in the form of HF [16]. Intracellular fluorides cause acid inhibition of enzymes, such as catalase, which can cause lipid oxidation and disrupt various metabolic pathways [17].

The demand for biological and organic preparations that stimulate growth and development processes to protect plants and increase soil fertility while improving the ecological situation in agroecosystems is increasing. Among them, TERIA-S bacterial fertilizer, produced on the basis of effective microorganisms, is widely used in agricultural practice. In our experiments, we carried out scientific research on the use of the above-mentioned bacterial fertilizer to grow winter wheat in soil conditions relatively polluted with fluorine compounds.

Plant seed germination is one of the most important criteria for evaluating the quality of crop seeds [18]. For this reason, based on laboratory experiments, we studied the effect of TERIA-S bacterial fertilizer on the germination of wheat seeds in soil conditions affected by fluorine compounds at different levels. This process is the first developmental stage of the physiological process of plants and continues with the growth of vigor.

Wheat seeds in the experimental variants were treated with TERIA-S bacterial fertilizer, and seeds in the control variant were treated with water. After one day of experiment, we observed good germination of wheat seeds and further development of seedlings was better compared to water treated seeds.

Therefore, we used TERIA-S bacterial fertilizer on seeds to carry out laboratory studies on soil with varying degrees of fluorine contamination. Figure 1 shows data on the growth and development of the root system of wheat seedlings treated with TERIA-S bacterial fertilizer for wheat seeds.

Figure 1. Effect of TERIA-S bacterial fertilizer on the development of wheat root system after 30 days of experiment (1-weakly damaged soil; 2-moderately damaged soil; 3-severely damaged soil; H-control, wheat treated with water before sowing seeds; and, T-experiment, wheat was treated with TERIA-S bacterial fertilizer before planting on seeds).

After a 30-day laboratory experiment with wheat, the effect of biometric parameters on the length of wheat seedlings was determined (Table 2).

Table 2. Effect of TERIA-S bacterial fertilizer on 30-day wheat seedling length in soils contaminated with different levels of fluoride.

Experience options	**Root length, cm**		**Length of the stems, cm**		**Total length of seedlings, cm**	
	control	**experience**	**control**	**experience**	**control**	**experience**
Weakly damaged soil	12.1 ±0.38	13.1 ±0.3*	19.2 ±0.26	22.0 ±0.28*	31.0 ±0.52	35.0 ±0.28*
Moderately damaged soil	10.4 ±0.08	12 ±0.28*	31.0 ±0.38	32.0 ±0.5*	41.0 ±0.38	44.0 ±0.42*
Severely damaged soil	10.6 ±0.13	11.3 ±0.4*	30.0 ±0.32	31.0 ±0.46*	40.6 ±0.32	42.2 ±0.36*
* P ≤ *reliable compared to control*						

Laboratory experiments were carried out on growing winter wheat in laboratory conditions and determining changes in biometric parameters when TERIA - S bacterial fertilizer was used in soil conditions contaminated with fluorine compounds. The reason for

low biometric k-indicators of wheat in the control option is the presence of fluoride in the soil. It has been proven that the effect of TERIA-S bacterial fertilizer on 30-day-old wheat seedlings in soils with different levels of fluoride contamination improved the biometric parameters several times (Table 3).

Table 3. Effect of bacterial fertilizer TERIA-S on the weight of 30-day-old wheat seedlings in soils contaminated with different levels of fluoride.

Experience options	Root weight, g		Stem weight, g		Total weight of seedlings, g	
	control	experience	control	experience	control	experience
Weakly damaged soil	2.32 ± 0.02	7.58 ±0.04*	1.35 ± 0.03	2.15 ±0.04*	3.67 ± 0.03	9.69 ±0.04*
Moderately damaged soil	3.54 ± 0.024	7.8 ±0.06*	1.40 ± 0.02	2.87 ±0.03*	4.94 ± 0.04	10.67 ± 0.04
Severely damaged soil	3.24 ± 0.04	5.40 ±0.07*	1.47 ± 0.02	1.49 ±0.02	4.69 ±0.05	6.89 ±0.04*
* P ≤ *more reliable than control*						

Laboratory experiments were carried out on growing winter wheat in laboratory conditions and determining changes in biometric indicators in soil conditions contaminated with fluorine compounds when TERIA - S bacterial fertilizer was used. It has been proven that TERIA-S bacterial fertilizer has repeatedly improved the biometric parameters of 30-day-old wheat seedling length and weight in soils contaminated with fluoride at different levels.

4 Conclusions

In the experiments carried out by us, it was proved that the biometric parameters such as the length and weight of wheat seedlings improved several times after planting these wheat grains with "TERIA-S" bacterial fertilizer on soils contaminated with fluoride at different levels. This fact shows that soil bacteria with a complex of beneficial properties contained in TERIA - S bacterial fertilizer develop well in the soil around the roots contaminated with fluorine to different degrees , allowing plants to develop better than the control.

Thus, it was determined that the use of TERIA - S bacterial fertilizer gives positive results in the deactivation of soil contaminated with fluorine compounds .

References

1. Rakshit PK Studies on estimation of fluoride and fluoridation of drinking water," Dissertation, IISc Bangalore, 2014.
2. Zohoori FV, Moynihan PJ, Omid N., Abuhaloob L, Maguire A. Impact of water fluoride concentration on the fluoride content of infant foods and drinks requiring preparation with liquids before feeding, Community Dental Oral Epidemiology, vol.40, 2012, pp. 432-440
3. Jagtap S., Yenkie MK, Labhsetwar N., Rayalu S. Fluoride in Drinking Water and Defluoridation of Water, Chemical Review, vol.112, 2012, pp. 2454-2466.
4. Polonsky V.I., Polonskaya D.E. Fluoride contamination of soil and phytoremediation // Agricultural biology. 2013. - No. 1 (18). - P. 3-14.

5. Ram A., Verma P., Gadi BR Effect of fluoride and salicylic acid on seedling growth and biochemical parameters of watermelon (Citrullus lanatus), Fluoride, vol. 47, 2014, pp. 49-55.
6. Pal KC, Mondal NK, Chatterjee S., Ghosh TS, Datta JK Characterization of fluoride-tolerant halophilic Bacillus flexus NM25 (HQ875778) isolated from fluoride-affected soil in Birbhum district, West Bengal, India, Environment Monitoring Assessment, 2014; vol.186, pp. 699-709
7. Baunthiyal M., Ranghar S. Physiological and biochemical responses of plants under fluoride stress: An overview, Fluoride, vol. 47, 2014, pp. 287-293.
8. Mondal N. K., Pal K. C., Dey M., Ghosh S., Das C., Datta J. K. Seasonal variation of soil enzymes in areas of fluoride stress in Birbhum district, West Bengal, India, Journal of Taibah University of Science, vol.9, 2015, pp. 133-142.
9. Kumar, T.S., Dhakaand, K.P., Singh A. Eect of fluoride toxicity on the growth and yield of wheat (Triticum aestivum L.). Int. J. Forest. Crop Impr. 2013, 4, 59–62.
10. Choudhary S., Rani, M., Devika O.S., Patra A., Singh R.K., Prasad S.K. Impact of fluoride on agriculture: A review on it's sources. toxicity in plants and mitigation strategies. Int. J. Chem. Stud. 2019, 7, 1675–1680
11. Snioszek M., Telesi´nski A., Smolik B., Zakrzewska H. Eect of Fluoride and Bentonite on Biochemical Aspects of Oxidative Stress in Pisum sativum LJ Ecol. Eng. 2018, 19, 164–171
12. Bogoslovsky V. N., Levinsky B. V., Sychev V. G. Agricultural technologies of the future. Book 1: Energens. M.: Antikva, 2004. 163 p.
13. Ogloblina R.I. Influence of fluorine and sulfur compounds on the abundance and composition of the soil microflora of the Minusinsk depression in the book: Basic questions of agrochemistry and soil science, Pushchino 2017.
14. Banerjee G., Sengupta A., Roy T., Banerjee PP, Chattopadhyay A., Ray AK Isolation and characterization of fluoride resistant bacterial strains from fluoride endemic areas of west Bengal, India: Assessment of their fluoride absorption efficiency. *Fluoride* 2016, 49, 429
15. Armor B.A. Methods of laboratory and field experience. - M.: Agropromizdat, 1985. – 351 p.
16. Marquis E., Clock SA, Meira MM Fluoride and organic weak acids as modulators of microbial physiology, FEMS Microbiology Reviews, 2002.
17. Spets H.S., Seppa L., Korhonen A., Alakujala P. Accumulation of strontium and fluoride in approximal dental plaqueand changes in plaque microflora after rinsing with chlorohexidine-fluoride-strontium solution, Oral diseases, vol. 4, 2018, pp. 114-11
18. Filho J.M. Seed vigor testing: An overview of the past, present and future perspective. Sci. Agric. 2015, 72, 363–374.