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Dynamics of wheat plant growth on oil-contaminated soils enriched with organic fertilizers

Q.S. Hasanov[1], A.I. Babayev[2], K.M. Ismailova[2,*], Z.O. Gakhramanova[2], N.A. Sadiqova[2], N.A. Yusubova[2], N.S. Bayramova[2]

[1] Azerbaijan State Oil and Industry University, 20 Azadlig Avenue, AZ1010, Baku, Azerbaijan

[2] Scientific Resarch İnsitute "Geotechnological Problems of Oil, Gas and Chemistry", 227 Dilara Aliyeva str., AZ1010, Baku, Azerbaijan

Abstract

In vegetation experiments, the effect of dry cotton leaves and bentonite suspension introduced into oil-polluted soil for enrichment in the process of wheat growth was determined. It was found that the introduction of both additives separately, and together, led to an increase in the growth rate of wheat. It was noted that the best result was obtained when crushed cotton leaves and dispersed bentonite suspension were introduced into the soil.

Keywords: oil, soil, wheat, pollutant, cotton leaves, bentonite, suspension, dispersion

*Corresponding author. Tel.: +994707719992

E-mail address: kamala.i@mail.ru

1.Introduction

Pollution of the environment by oil and its products is a pressing economic problem affecting the environmental interests of many countries. Oil pollution primarily leads to a strong negative impact of pollutants on the properties of soils, degradation and even complete destruction of biocenoses due to increased hydrophobicity and filling of soil capillaries with oil, as well as the toxic effect of oil hydrocarbons [1].

In this regard, various rational technologies for cleaning and extracting oil products from soil have been proposed. Due to the wide variety and composition of oil pollution, there is currently no single scientifically based approach to solving this problem. These technologies are based on existing methods of influencing oil-polluted soils: extraction with various organic solvents, electrochemical separation of the chemical part, press filtration, use in road and industrial construction, as components in the production of various products.

The aim of our research was to study the effect of enriching soils with a moderate degree of oil pollution (2%) by adding dry cotton leaves and bentonite suspension (montmorillonite) [2].

The proposed enrichment method requires careful grinding of dry cotton leaves in order to prevent the process of rotting, increase growth and strengthen the roots of wheat. Also, the bentonite used was pre-dispersed in order to enrich the soil with mineral additives and increase its fertility, while a colloidal suspension or gel is formed.

We first introduced the prepared organic fertilizer into ordinary soil and studied the efficiency of wheat plant growth. Based on the results of the experiments, a patent was presented "Method of enriching soil for grain crops" and a positive decision was received.

The properties of bentonite, such as hydration, swelling, water absorption, viscosity, make it a valuable material for a wide range of applications. The formed tiny particles of bentonite contribute to a more uniform distribution of macro and microelements in the used volume of soil [3].

The crushed bentonite powder was mixed with water and subjected to ultrasonic treatment at a frequency of 20 kHz in an Ultrasonic Cell Crusher Noise Isolating Chamber, which produced bentonite particles of 20 nm in size.

These particles were examined using a transmission electron microscope. Below is an image of bentonite nanoparticles, they have a layered structure. The dark part of the nanoparticles has a more layered structure, and the light part has a less layered structure.

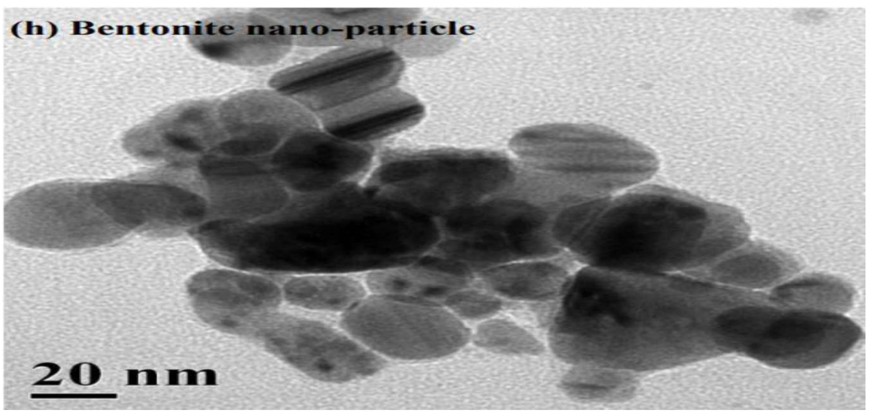

Figure 1. Transmission microscope image of dispersed bentonite

Dispersion contributes to a more advantageous use of bentonite. Its particles should be uniformly distributed in the base medium. Bentonite dispersion was carried out in water, while a colloidal suspension was formed. Such bentonite has a high swelling capacity and can adsorb a large amount of liquid. Of the existing dispersion methods, ultrasound is preferable for obtaining high-quality bentonite suspensions [4],[5]. Ultrasonic treatment exfoliates bentonite, which leads to a high particle surface, and then to improved swelling and fungionalization of bentonite.

To implement the proposed method, cotton leaves were used, which are waste after cotton harvesting. The chemical composition of the cotton leaves used is presented in Table 1.

Mineral composition of cotton leaves burned at 6000 C, in PPm

1) (MgO64(Ca936)(CO3);　　2) SiO2

3) Ca(PO3)2;　　4) KNa(SO4)

The composition of high-quality bentonite mined in Azerbaijan from the Dash-Salakhly (Kazakh) is shown in Table 2.

Table 1. Results of analysis of the presented sample, in % (mass.)

Conventional name	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	Fe_2O_3	Cl	ПВ
Cotton leaves	0,33	1,57	0,28	1,07	0,91	2,4	3,18	6,10	0,12	0,003	83,9

Table 2. Chemical composition of bentonite from the Dash-Salakhly, % (mass)

Chemical compounds	Si O_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	CaO	MgO	P_2O_5	SO_3	K_2O	Na_2O
Quantity	58,60	13,40	4,70	0,18	0,39	2,05	2,30	0,11	0,25	0,39	2,30

2. Methodological part

Laboratory and vegetation experiments to determine phytoproductivity were conducted at an ambient temperature of 24-25°C under natural light. Using periodic weighing, soil moisture was maintained at 55-60% of the full moisture capacity.

At the same time, the rate of moisture evaporation from a vessel with soil with a similar concentration of oil, but without plants, was measured. Spring wheat was used as a test object. Seed germination was more than 95%. The original oil-contaminated soil without additives served as a control. Plastic containers with a diameter of 13 cm and a volume of 600 ml were used as vegetation vessels.

Organic fertilizer was prepared as follows: 100 g of dry cotton leaves were taken, ground in a mortar, as well as 1 g of powdered bentonite and 20 ml of water. To conduct the experiments, 4 containers were filled with 100 g of soil to a depth of 3-4 cm, oil was added to its surface, creating an oil concentration as indicated above.

In 1 container with prepared initial soil, 5 g of wheat grains were planted. Watering was carried out periodically and the height of the sprouts was observed (blank experiment).

In the 2nd container, 30 g of dry powdered cotton leaves were added to the existing soil, mixed with the soil, then 5 g of wheat grains were planted, periodically watered and growth was observed.

In the 3rd container, 30 g of dry crushed cotton leaves, 1 g of crushed bentonite in 20 ml of water were added to the existing soil. The entire mass was mixed with soil, then 5 g of wheat grains were planted. Watering was carried out and the height of the sprouts was observed. In the 4th container, 30 g of dry crushed cotton leaves were added to the soil there, and 20 ml of the prepared dispersed bentonite suspension (1 g of bentonite + 20 ml of water) was added. The contents of the container were thoroughly mixed, 5 g of wheat grains were planted and watered, then the height of the sprouts was observed. 20

seeds were planted in the experimental and control containers. During the first week of the experiment, the height of the plants was measured daily, then 2–3 times a week.

The remaining plants were observed for 30 days. Two days after sowing, wheat sprouts began to appear in all containers. Periodically, the contents of all containers were watered, and the increase in the growth of grain sprouts continued to be observed.

2. Results and discussion

Table 3.

Date of observation	No additives	Amount of added cotton leaves and bentonite, g		
		Dry leaves 30	Powder+leaves 1+30	Suspension + leaves 20+30
	Stem height, cm			
01.05.2024	1	3	3,5	4
03.05.2024	3	4	5	7,5
06.05.2024	4	5,5	6	11
08.05.2024	9	8	10	15
10.05.2024	11	12	13	18
13.05.2024	13	14	15	21
14.05.2024	14	16	18	23,5
16.05.2024	15	17,5	19	25
20.05.2024	17	19	20,5	24
22.05.2024	19	22	22	28
24.05.2024	20	23	24	31
27.05.2024	21	24	26	32
29.05.2024	22	25,5	28	33
31.05.2024	22,5	26	29	34
03.06.2024	23	27	30,5	35

Experiments have shown that when organic fertilizer with mineral additives was added to slightly polluted soil, a tendency towards a regular increase in wheat growth was revealed. Moreover, stimulation of growth height directly depended on enrichment methods and on the combination of organic additives added to the soil. The results of observations are presented in Table 3.

As can be seen from Table 3, at the beginning of the experiment, the first day, a virtually insignificant difference in the germination of wheat seeds was observed. Then, inhibition of growth processes was observed in the control experiment, especially in the second half of the month, which is due to a decrease in the level of resistance of organisms, or an increasing damaging effect of the pollutant. The latter is a consequence of the formation of a hydrophobic film on the roots, which creates a deficit of oxygen, water and mineral elements. A significant difference from the control experiment was observed in plant growth in oil-polluted soil enriched with organic fertilizers.

When comparing the blank experiment with the other experiments, where crushed cotton leaves were added to the soil, as well as crushed and ultra-dispersed bentonite, the initial germination and further growth were more intensive. The best result was observed when using a modification of cotton leaves in the amount of 30 g with a dispersed suspension of bentonite 1 g + 20 ml of water, added to 100 g of oil-contaminated soil.

4. Conclusion

As experimental data have shown, the use of dry cotton leaves as an organic fertilizer at a rate of 80.5-90 kg/ha, and as a mineral additive a dispersed suspension of bentonite in an amount of 40-50 kg/ha will enrich the soil and ensure more intensive growth of grain crops.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research.

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