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ASSESSMENT OF PHYTOTIC TOXICITY OF MIXED AVIATION FUELS USING OF PLANT TESTERS

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Abstract. The possibility of using plant tests to evaluate fuel toxicity has been investigated. Plant tests to be susceptible to contamination by mixed aviation fuels in the early stages of plant germination have been found. Indicator plants with mixed aviation fuels that respond to low fuel content in the soil at the approximate permissible concentration level have been established. The specificity and sensitivity of phytotests (Lolla Rossa lettuce and Rudolph radish) were revealed, which indicates the possibility of their use for the toxicity assessment of oil-contaminated soils.
Keywords: *toxicity, biotests, plants, aviation fuel, biofuel, soil, phytotests, indicators, pollutants.*

Introduction

Degradation of vegetation and soil due to man-made activity is one of the most important environmental problems of today. Vegetation and soils is a powerful biochemical barrier that concentrates air migrants and pollutants of various origins.

Environmental protection is only possible with reliable information on the ecological status of contaminated soil. With the help of chemical-analytical methods it is not possible to evaluate ecosystems from biological positions, because the effects of synergism, antagonism and the total effect of toxicants are not taken into account [1-5]. That is why modern environmental monitoring in case of contamination by oil should optimally include not only the study of the level of petrochemical contamination and changes in the physical and chemical properties of soils, but also the environmental assessment carried out by biotesting and bioindication methods. The use of plant tests is promising due to the availability, easy research, cost-effectiveness, reliability. However, the environmental assessment of oil-contaminated soils using plants remains unresolved.

Due to this the environmental assessment of soils contaminated with petroleum products using plant tests, which should be the first stage in the diagnosis of soil quality is important research area. Oil and petroleum pollution is one of the most dangerous types of environmental pollution. Its negative impact on soil and vegetation, the atmosphere, surface and groundwater, human health is noted at all stages of industrial development: extraction, processing, storage, transportation and disposal of equipment. Aquatic and terrestrial ecosystems are most affected. Among the components of terrestrial ecosystems, soil is primarily polluted. Due to its high adsorption capacity, oil and petroleum products are stored there for a long time, causing both land degradation and the danger of pollutants entering into the food chains, one of which is human.

Modern long-haul and regional aircrafts require large fuel reserves in tanks, which in turn necessitates the availability of bulk oil depots and fuel and lubricant depots near airports. Considering large volumes of aviation fuels at transporting, storing and refuelling, there is always a high risk of fuel spillage and absorption by soil. Also, it should be noted that in the media, there are more and more promotional and propaganda information about biofuels use. This issue is also relates to aviation, and although civil aviation aircrafts today are not fueled with biofuels, more and more countries are developing blended aviation fuels from petroleum and natural organic raw materials. Therefore, given the above, the question of the toxicity assessment of aviation oil and mixed fuels in case of their entry into the soil remains relevant.

Analysis of the latest researches and publacations

It is known that in the case of oil contamination there is a violation of the structural and functional characteristics of the soil ecosystem, a decrease in soil productivity, a change in the morphological characteristics, physical, chemical and biological properties of soils [6-8].

Morphological changes include: a darker color compared to unpolluted soil, higher density, the presence of oil films, the appearance of a columnar structure at the bottom of the soil profile [9]. In oil-contaminated soils, black, gray-brown shades in the upper part of the profile and dark brown, brown-brown, brownish-brown predominate in the lower [10]. Changing the color of the soil surface as a result of covering the soil particles with an oil film leads to a decrease in its spectral reflectivity, and therefore to its greater warming [11].

Vertical advancement of oil along the soil profile creates a chromatographic effect of differentiation of the composition of the oil: in the upper, humus horizon, high molecular weight components containing many tar-asphaltene substances and cyclic compounds are sorbed; in the lower horizons penetrate mainly low molecular weight compounds that have a higher solubility in water than high molecular weight components [12, 13].

Scientists have found in laboratory studies [5, 14] that the main processes that determine the migration of hydrocarbons are the sorption and permeability of the soil. As soil density increases, the amount of adsorbed oil and petroleum products increases. With increasing soil moisture, there is a decrease in sorption of petroleum products, but the depth of their vertical migration increases [15]. In the case of oil entering the soil of the sand granulometric composition, its active migration with subsequent accumulation in the lower horizons, as well as the outlet in the soil and groundwater is observed [16]. Also, as a result of oil and petroleum contamination, the number and ratio of macro- and micro-elements change. In particular, the ratio of carbon to nitrogen sharply increases due to the carbon of oil, which degrades the nitrogen regime of soils [17]. In addition, oil has a negative impact on the bacteria involved in the nitrogen cycle [18].

The authors of works [15, 19, 20] have found that oil contamination leads to the restructuring of the soil-absorbing complex, which in turn leads to a shift of alkaline-acidic soil conditions and there is a lengthening of the initially acidic and slightly acidic soils, or close to acidic soils. and neutral soils at 0.1 -0.3 pH units [20]. In the case of oil contamination of initially neutral meadow-alluvial soil, acidification of the soil solution by 0.8-1.6 pH units was observed [21].

The authors of works [10, 17, 22, 23] have investigated that biological properties of soils also change dramatically in response to oil pollution, and the activity of most soil enzymes is reduced. But in the works [19, 23], the activity of catalase dehydrogenase, urease [17, 21], invertase [24] is increased.

Many researchers have found that aromatic hydrocarbons inhibit the activity of enzymes, paraffin - activate. Changes in the activity of soil enzymes usually correlate with the number of microorganisms [22]. Petroleum hydrocarbons affect microorganisms through transformation of soil physicochemical properties: reduced availability of mineral nutrients, deterioration of water and air modes, change of reaction of soil environment and soil structure [25], and direct toxic effect, which is associated with, first, volatile aromatic hydrocarbons (benzene, toluene, xylene, etc.), naphthalene and some other water-soluble compounds [17].

Analysis of publications shows that the impact of oil on the complex of soil microorganisms is quite ambiguous. It is established that oil pollution stimulates the growth of certain species and inhibits the development of others, which depends on the concentration and composition of the pollutant and the biological characteristics of organisms. Actinomycetes, nitrifiers and cellulosic microorganisms are the most sensitive to oil pollution. In contrast to the decrease in the number or complete loss of the most sensitive units of soil microbial grouping, there is an increase in the number of oil-oxidizing microorganisms and micromycetes that use hydrocarbon oils as a nutrient substrate.

The effect of oil pollution on plants occurs in two ways: directly, as a result of the penetration of the oil components through the root system or the expiration of the leaves with their inclusion in the metabolism, and indirectly, through changes in the physical and chemical composition of the soil and, accordingly, the violation of its biotic properties. The penetration of components of liquid fractions of petroleum products into the plant organism through the root system causes mutagenic reactions, morphogenetic and phenological deviations from normal development [5].

It's found that low concentrations of petroleum and petroleum products in the soil (according to various data up to 5%) have no significant effect or even to stimulate plant growth, increasing such indicators as germination, biomass, length of aboveground or underground part, chlorophyll content in leaves. With further increase of oil content in the soil, a significant inhibitory effect or complete loss of plants begins to appear [19, 26].

It is known that the level of soil contamination that exceeds the limit of self-purification potential is considered dangerous. Soils are considered contaminated if the concentration of petroleum products in them reaches a value at which negative environmental changes in the environment begin: ecological balance in the soil ecosystem is disturbed, soil biota dies, productivity decreases or there is a loss of plants, morphology changes , their fertility is reduced and groundwater and surface water are at risk of contamination. That is why the primary task when performing soil contamination analysis is to determine the permissible or safe content standards for this type of contamination.

In Europe, it is considered the highest safe level of oil content in soil 1-3 g/kg, the beginning of serious environmental damage - 20 g/kg and above. In the near-abroad countries, maximum permissible concentrations (MPC) of oil products in the soil have not been developed, except for Tatarstan (Russia). For Tatarstan, the MPC of petroleum products in the soil is 1.5 g/kg, which corresponds to the translocation (phytoaccumulation) indicator of harmfulness. They also use a migratory water hazard (13.1 g/kg), migratory air (more than 5 g/kg) and general health (more than 5 g/kg) [5].

In Ukraine, the MPC of oil and its products in the soil is not defined, there is only a reference to the concentration limit of 0.2 mg/kg [27]. Sources [26, 28] have determined the concentration for soil - 4 g/kg, which is widely used for soil contamination by petroleum products. Targeting this indicator cannot guarantee objective estimates, especially since the clarity of oil hydrocarbons content in the soil in European countries ranges from 0.01 -0.5 g/kg, and in large cities of Ukraine quite usual indicators 1-3 g/kg. In the territories adjacent to oil refining, extraction and storage enterprises, the background reaches 6 g kg.

According to [29], it is proposed to set the following gradations of soil and oil contamination for the black earth zone of Ukraine: unpolluted - less than 400 mg/kg (0.4 g/kg); slightly contaminated - 3000-6000 mg/kg (3-6 g/kg); average contaminated - 6000-12000 mg/kg (6-12 g/kg); heavily contaminated - 12000-25000 mg/kg (12-25 g/kg); very contaminated - over 25,000 mg/kg (> 25 g/kg).

High stability and toxicity, variability of hydrocarbon composition, absence of the established MPC standards for most of the petroleum products, impossibility of taking into account the ecological danger of the combined action of hydrocarbons, products of their decomposition and interaction with those present in water and soil problems.

Current environmetnal monitoring is carried out with obligatory use of biological methods: bioindications and biotesting, which take into account the whole complex of negative factors of action on a living organism, as a set of primary toxicants, which got into the environment, and a set of reaction products between primary chemical compounds 1, 2 5, 19].

Bioindication of contamination, based on the study of various biological, physiological, anatomical and other abnormalities in the development of organisms, as well as their communities arising from external factors, is widely used in the monitoring system. These methods are inexpensive and able to simultaneously cover large areas to be indicated, as well as the relative ease of interpretation. The basic condition for successful indication is a clear reaction-response to a physical or chemical action that is specific, easily recorded visually or using devices [2, 5].

A related bioindication method is biotesting, which is used to determine the total toxicity of the environment and, unlike bioindication, characterizes the degree of impact of pollution on the ecosystem at a specific time of sampling. These methods are close to the methods of chemical analysis and allow to give a real assessment of the toxicity of complex contamination with chemicals. It has been reported [5, 30] that the use of biological test systems allows the detection of negative changes in ecosystems at a very early stage, when they are not yet manifested as morphological and structural changes and cannot be detected by other methods. This makes it possible to anticipate ecosystem disturbance and take appropriate action in advance.

Due to the availability, simplicity and timeliness of biotesting, it is widely recognized worldwide and is increasingly used in modern environmental monitoring systems. Biotests are recommended for continuous express control of the environment of industrial areas and natural-economic complexes, control of harmful emissions of enterprises, to assess the effectiveness of the methods used for environmental detoxification and operation of treatment facilities, environmerntal certification of enterprises and individual areas.

Biotesting methods must meet the following requirements: expressiveness, accessibility and ease of implementation; reproducibility and reliability of the obtained results; cost effectiveness, both in financial terms and labor costs; objectivity of the obtained data [3]. The basic principle of biological testing is to evaluate the significant difference of any test parameter of the test object, indicating complete or partial inhibition of the vital functions of the test organisms in the experiment (toxic environment) and control (clean environment).

Plants are considered to be the most suitable sites for soil biomonitoring, since they are the primary links of trophic chains and play a major role in the absorption of a variety of pollutants. They are characterized by the availability, ease of cultivation, high sensitivity to a number of pollutants, the ability to evaluate the total effect of harmful substances on the soil ecosystem. Their short-term, simple-to-perform studies do not require sophisticated laboratory equipment [5, 30, 32]. Also, plants are a cheap resource of biological material that is not demanding of the nutrient medium in the initial stages of ontogeny, since seedlings and seeds themselves contain the required amount of spare substances [20].

Due to the genetic heterogeneity of plants, their different species and varieties respond differently to the effects of pollutants.

Biotesting and bioindication of oil-contaminated soils in agroecosystems is carried out on the basis of reactions of agricultural plants with different sensitivity to this factor [1, 2, 5, 23, 28].

Many domestic and foreign works show the effectiveness of the use of seeds of salad *(Lepidiumsativum)*. It is one of the most commonly used test objects used for biotesting of water, sediments, soils, natural and man-made substrates, radiation exposure, the effects of synthesized chemicals and mixtures thereof [5]. This test culture is informative for environmental contamination by pollutants of various types (heavy metals, hydrocarbons, radioactive substances, etc.) and at complex contamination.

In the papers [23, 35], a method for determining the total toxicity of soil using seed of radish *(Raphanussativusvar. RadiculaPers.)* Is reported, which is related to the high sensitivity of seeds to toxic substances. The phytotoxicity of oil-contaminated soils is also evaluated using radishes.

Sorghum *(Sorghumbicolor L.)* and beans *(Phaseolusvulgaris L.)* are used to determine the toxicity of jet fuel and herbicides. Millet root growth (*Panicummiliaceum L.*) Serves to determine the toxicity of phenols and chlorophenols [36]. The effectiveness of using onion seeds *(Alliumcepa L.)* as an effective test culture for the study of the toxic effects of a wide range of chemicals has been demonstrated.

In his writings S. Illarionov [37] studied the phytotoxicity of oil-contaminated soils using clover. Phytotoxicity indicators were a decrease in germination and seed survival, as well as the weight of dry biomass of grown plants.

According to the international standard ISO 11269-1 it is recommended to use barley *(Hordeum vulgare)* for biotesting. At the same time it is stated that it is possible to apply seeds and other plants. The international standard ISO 11269-2 regulates the selection of at least two species of plants, one being monocotyledonous and the other dicotyledonous [38].

In the works of foreign scientists [39], this effect was demonstrated in relation to the sensitivity of lettuce, sorghum and mustard seeds on soils contaminated with complexes of heavy metals and petroleum products, including surfactants. Plants are shown to be in the following order to reduce soil toxicity: *Lepidium sativum <Sinapis alba <Sorghum saccharatum.*

In other studies of phytotesting of contaminants (phosphogypsum waste, soil biomaterials, nanomaterials) carried out on white mustard seeds *(Sinapis alba)*, the use of this crop has been demonstrated as it has shown good similarity and reproducibility of results in experiments [34].

The authors [35] established the difference of reactions of seeds of agricultural plants to the action of petroleum products. By reducing the sensitivity to petroleum products, the studied plants are placed in the following order: barley, radishes, lettuce.

In the diagnosis and assessment of toxicity of oil-contaminated soils, usually such factors as plant height, number, length and width of leaves, length of shoots, number and length of shoots, number of flowers, size of perianth parts, number of fruits and seeds in the fruit, total weight plants and the mass of its individual parts and the like. Physiological, biochemical and cytogenetic parameters of plant test systems are suitable for quantitative assessment of the effect of factors in conditions of technogenic contamination [5, 26, 28].

In general, plants are promising test objects for biomonitoring due to their high sensitivity to environmental changes due to anthropogenic factors.

The purpose and objectives of the study

The purpose of the work consist in evaluation the toxicity of mixed aviation fuels using plant test objects.

To achieve this goal, the following tasks were defined:

1. Specify plant test objects that are susceptible to contamination by mixed aviation fuels in the early stages of germination. Establish a connection between the content of aviation fuel in the soil and the initial growth parameters of the test plants.

2. Identify the plant-indicator to contamination with mixed aviation fuel, which responds to the low fuel content in the soil, at the level of the estimated permissible concentration.

Material and research results

During the development of the method of biotesting and bioindication of soils contaminated with mixed aviation fuel, we searched for plants that are sensitive to oil pollution and determined the connection between the concentration of aviation fuel in the soil and morphometric indicators of sensitive phytotests.

For experimental studies, this work used plants that, according to the analysis of literary sources, best proved themselves to biotest soil contaminated with oil: seeds of Lola Rossa lettuce, Rudolph radish, peas, beans and cucumber.

For research, we used artificially contaminated mixed aviation soils, which were prepared according to the following scheme: in air-dry turf-podzolic pure soil, sifted through a sieve with openings of 1 mm, added to JETA-1 aviation fuel, rapeseed biofuels and blended aviation (JETA -1 + rapeseed biofuels). The experiments were conducted in the laboratory of Alternative Motor Fuels of the National Aviation University of Kyiv.

During planting: pot No. 1 was poured with a water emulsion with a concentration of 5% biofuel, No. 2 - a water emulsion with a concentration of 10% biofuel, No. 3 - a water emulsion with a concentration of 5% (50:50 JETA-1: biofuel), No. 4 - a water emulsion with a concentration of 10% (50:50 JETA-1:biofuel), No. 5 - a water emulsion with a concentration of 5% (30:70 JETA-1:biofuel), No. 6 - a water emulsion with a concentration of 10% (30:70 JETA1:biofuel), No. 7 - an aqueous emulsion with a concentration of 5% JETA-1, No. 8 - an aqueous emulsion with a concentration of 10% JETA-1 - biofuels.

The control sample was a sample of soil that was watered with clean water. The experiment was carried out for 15 days. After incubation, the number of sprouted seeds was recorded and the height of the stems was measured every day.

All of the above was repeated with radish, peas, beans and cucumber seeds.

During germination, the tester plants measured the length of the root, the height of the shoot, and their relative values. Fixed plant growth by days of germination.

We have evaluated the toxicity of soils contaminated with various fuels by phytotesting methods. A linear relationship between the inhibition of root and shoot growth of the studied phytotests and the degree of contamination was established.

Figure 1 shows the effect of rapeseed-based biofuels on the Lola Rossa lettuce and Rudolph radish growth. Seeds of peas, beans and cucumbers almost did not sprout during watering with different concentrations of aviation fuel and rapeseed biofuels, and sprouting shoots died on day 2, 3. Therefore, we have concluded that these plants are not suitable for bio-indication of aviation fuels.

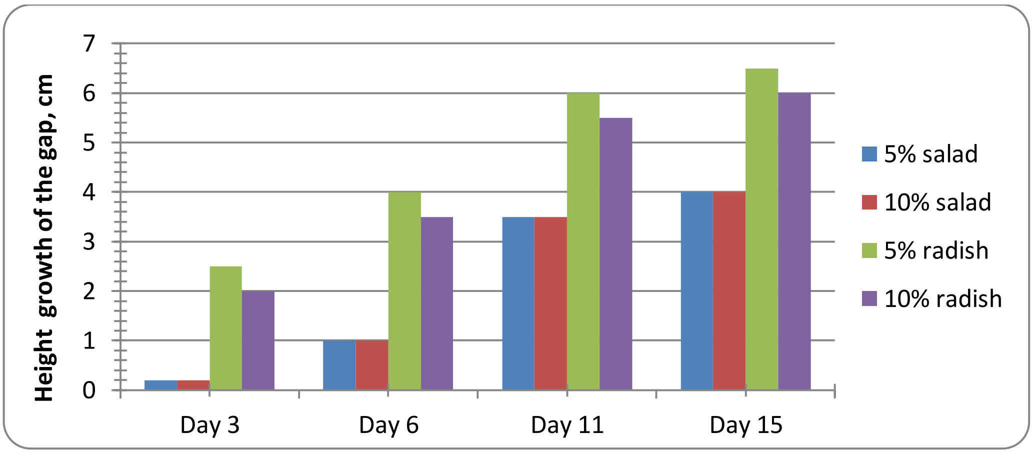

Fig. 1. Dynamics of influence of different concentrations of biofuels on Lola Rossa lettuce and Rudolf radish growth rates

From fig. 1. it can be seen that the addition of biofuels in different quantities affects the growth of Lola Ross lettuce and Rudolph radish. In the case of increasing the concentration of biofuels there is a noticeable acceleration of growth and germination of stems, plant growth also increases in comparison with the seeds watered with pure water.

On the 3 day the lettuce height watered with a concentration of 50 ml - 0.2 cm, the radish height watered with a concentration of 50 ml - 2.5 cm; lettuce height watered with a concentration of 100 ml - 0.2 cm, radish height watered with a concentration of 100 ml - 2 cm. On the 6 day the lettuce height watered with a concentration of 50 ml - 1 cm, radish height watered with a concentration of 50 ml - 4 cm; lettuce height watered with concentration of biofuel 100 ml - 1 cm, radish height watered with concentration of 100 ml - 3.5 cm. On the 11 day the lettuce height watered with concentration of 50 ml - 3.5 cm, radish height watered with concentration of 50 ml - 6 cm; lettuce height watered with concentration of 100 ml - 3.5 cm, radish height watered with concentration of 100 ml - 5.5 cm. On the15 day the lettuce height watered with concentration of 50 ml - 4 cm, radish height watered with concentration of 50 ml - 6.5 cm; lettuce height watered with a concentration of 100 ml - 4 cm, radish height watered with a concentration of 100 ml - 6 cm. When adding 50 and 100 ml of biofuels, we see that the plants growth accelerates, ie, biofuel works as a stimulant.

Influence of various concentrations of aviation fuel-biofuel mix on Lola Ross lettuce and Rudolf radish growth.

To evaluate the toxicity, we germinated seeds of various types of Lola Rossa lettuce and Rudolph radish on soils contaminated with JETA-1-biofuel (50:50) at a concentration of 50 and 100 ml per 1000 ml of water.

From the results of Fig. 2 it can be concluded that in the case of increasing the concentration of JETA-1-biofuels (50:50), the plant growth does not change significantly.

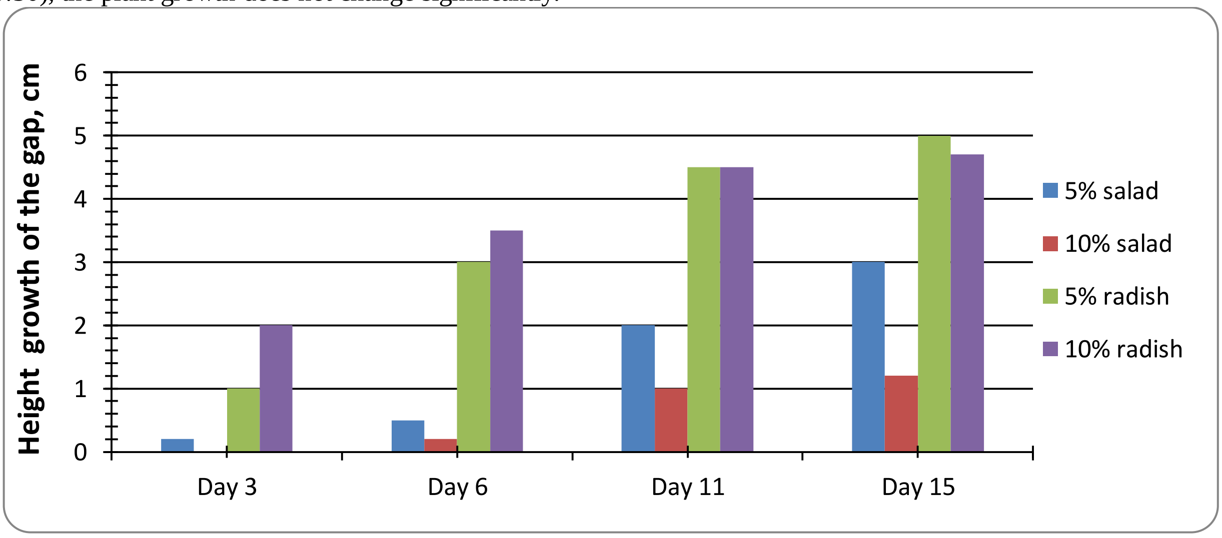

Fig. 2. Dynamics of the influence of different concentrations of aviation fuel and biofuels mixture (50:50) on the Lola Rossa lettuce and Rudolf radish growth height

On the 3 day the lettuce height watered with a concentration of 50 ml was 0.2 cm, the radish height watered with a concentration of 50 ml was 1 cm; lettuce height watered with a concentration of 100 ml was 0 cm, radish height watered with a concentration of 100 ml - 2 cm. On the 6 day the lettuce height watered with a concentration of 50 ml was 0.5 cm, radish height watered with a concentration of 50 ml - 3 cm; letucce height watered with a concentration of 100 ml was 0.2 cm, radish height watered with a concentration of 100 ml was 3.5 cm. On the 11 day the lettuce height watered with a concentration of 50 ml was 2 cm, radish height watered with a concentration of 50 ml was 4.5 cm;

lettuce height watered with a concentration of 100 ml was 1 cm, radish height watered with a concentration of 100 ml - 4.5 cm. On the 15 day the letucce height watered with a concentration of 50 ml was 3 cm, radish height watered with a concentration of 50 ml was 5 cm; the lettuce height watered with a concentration of 100 ml was 1.2 cm, the radish height watered with a concentration of of 100 ml was 4.7 cm. Compared to samples that were watered with different concentrations of biofuels, the samples of this experiment had a somewhat depressed height of stems. In our opinion, this can be explained by the fact that biofuel acts as a fertilizer (stimulant), and aviation fuel inhibits plant growth. And, since the ratio of JETA-1 to biofuels was 50:50, plant growth did not change significantly.

Influence of different concentrations of the mixture aviation fuel - biofuels (70:30) on the Lola Rossa lettuce and Rudolf radish growth.

In Fig. 3 we can see how the addition of JETA-1-biofuel (70:30) at different concentrations (50 and 100 ml per 1000 ml of water) affects the growth of Lola Rossa and Rudolph radish.

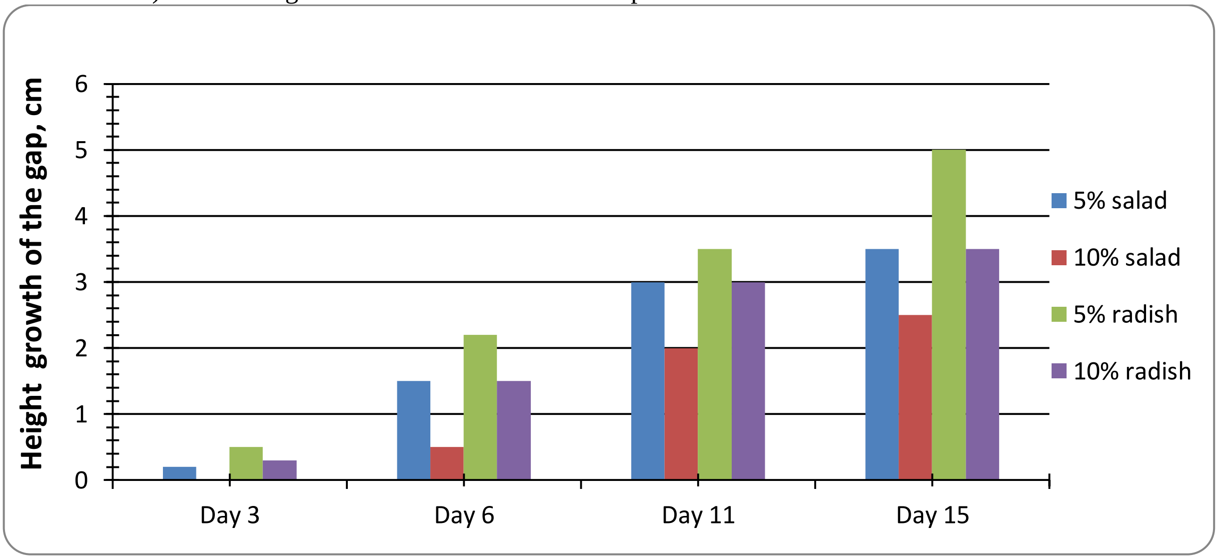

Fig. 3. Dynamics of the influence of different concentrations of a mixture of aviation fuel and biofuels (70:30) on the Lola Rossa and Rudolf radish growth

As you can see, when you add 50 and 100 ml of JETA-1-biofuel (70:30) per 1000 ml of water, there is a slowdown in the growth and germination of stems. On the 3 day the lettuce height watered with a mixture of 50 ml was 0.2 cm, the radish height watered with a mixture of 50 ml - 0.5 cm; lettuce height watered with a mixture of concentration 100 ml was - 0 cm, radish height watered with a concentration of 100 ml - 0.3 cm. On the 6 day the lettuce height watered with a mixture of 50 ml - 1.5 cm, radish height watered with a concentration of 50 ml - 2.2 cm; lettuce height watered with a mixture of concentration 100 ml was 0.5 cm, radish height watered with a mixture of concentration 100 ml - 1.5 cm.

On the 11 day the lettuce height watered with a mixture of 50 ml was 3 cm, the radish height watered with a mixture of 50 ml - 3.5 cm; lettuce height watered with a mixture of concentration 100 ml was 2 cm, radish height watered with a concentration of 100 ml - 3 cm. On the 15 day lettuce height watered with a mixture of concentration 50 ml was 3.5 cm, radish height watered with a concentration of 50 ml - 5 cm; lettuce height watered with a mixture of concentration 100 ml was 2.5 cm, radish height watered with a concentration of 100 ml - 3.5 cm. As you can see, when you add 50 and 100 ml of a mixture of 70:30 JETA-1-biofuels, plants have worse growth dynamics than when you add a mixture of JETA-1-biofuels 50:50. This can be explained by the fact that aviation fuel, which is twice as much, acts as a plant growth inhibitor.

Influence of different concentrations of JETA-1 aviation fuel on the Lola Rossa lettuce and Rudolf radish growth.

In Fig. 4 shows how JETA-1 aviation fuel affects the Lola Ross salad and Rudolph radish growth. The following concentrations of JETA-1: 50 and 100 ml per 1000 ml of water were used for the experiment.

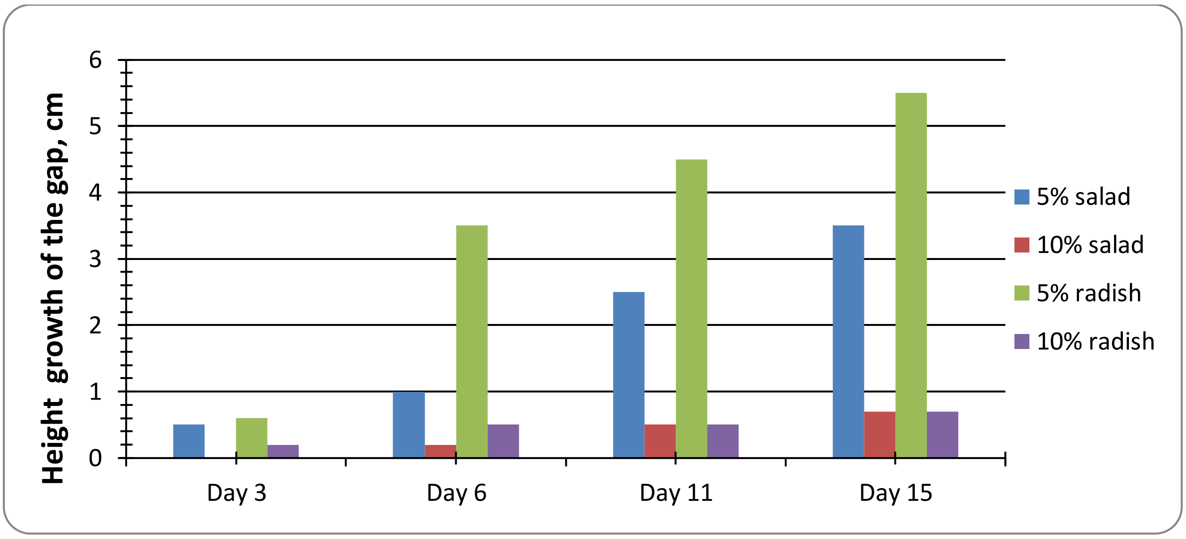

Fig. 4. Dynamics of the influence of JETA-1 on the Lola Rossa lettuce and Rudolph radish growth

Dependencies lead to the conclusion that as aviation fuel concentration increases, plant growth decreases, and when JETA-1 is added at a concentration of 100 ml, the plant is almost unchanged. On the 3 day, the lettuce height watered with a concentration of 50 ml was - 0.5 cm, the radish height watered with a concentration of 50 ml - 0.6 cm; lettuce height watered with a concentration of 100 ml was - 0 cm, radish height watered with a concentration of 100 ml - 0.2 cm. On the 6 day the lettuce height watered with a concentration of 50 ml was 1 cm, the radish height watered with a concentration of 50 ml was 3.5 cm; lettuce height watered with a concentration of 100 ml was 0.2 cm, radish height watered with a concentration of 100 ml - 0.5 cm. 5 cm; On the 11 day the lettuce height watered with a concentration of 50 ml was - 2.5 cm, the radish height watered with a concentration of 50 ml - 4.5 cm; lettuce height watered with a concentration of 100 ml was 0.5 cm, radish height watered with a concentration of 100 ml - 0.5 cm. On the 15 day the lettuce height watered with a concentration of 50 ml was - 4.5 cm, the radish height watered with a concentration of 50 ml - 5.5 cm; lettuce height watered with a concentration of 100 ml was 0.7 cm, radish height watered with a concentration of 100 ml - 0.6 cm.

Conclusions

1. It is established that the Lolla Rossa lettuce and Rudolph radish are sensitive to the content of JETA-1 aviation fuel and JETA-1 blended aviation fuel in soil in the early stages of germination in a wide range of 0-20% polutant concentration.

2. It is determined that to estimate the toxicity of measuring the initial growth parameters of these plants obtained on the 6 day of growth in the dark is optimal.

3. Plants: peas, beans and cucumbers are not suitable for testing the toxicity of aviation fuel JETA-1 and mixed aviation fuel JETA-1 - biofuels since they were killed at the germination stage.

4. To obtain quantitative characteristics of the effect of pollutants, we determined the connection between the response of the plant to the stress factor and the dose of the factor. To do this, the corresponding parameters (similarity, root length, etc.) were compared with the corresponding doses (concentrations) of the factor to obtain the dose-effect (concentration-effect) dependence on which the graphs were constructed.

5. We found that adding 50 ml of JETA-1 aviation fuel to the height of Lola Rossa lettuce and Rudolph radish left nearly identical samples, which we watered with 70:30 JETA-1 biofuels and decreased compared to the samples that were we poured 50 ml biofuels and 50 ml JETA-1-biofuels 50:50.

6. In the case of watering the plants with a water concentration of 100 ml JETA-1, the stem growth inhibition was more noticeable. Compared to samples that were splashed with a water concentration of 100 ml of JETA-1-biofuel (70:30) and samples with a spilled water concentration of 100 ml of JETA-1 had twice the height of the stem compared to samples splashed with water concentrations of 100 ml of JETA-1-mixture of JETA kerosene (50:50). Plants watered with a concentration of 100 ml of JETA-1 had 4-6 times lower stem height.

7. Specificity and sensitivity of phytotests (Lolla Rossa lettuce and Rudolph radish) were revealed as a result of the conducted studies, which indicates the possibility of their use for the toxicity assessment of oil-contaminated soils.

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