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Tolerance of cultivated and wild plants of different taxonomy to soil contamination by kerosene

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ABSTRACT

In laboratory experiments on leached chernozem contaminated by kerosene (1–15 wt.%), germination of 50 plants from 21 families (cultivated and wild, annual and perennial, mono- and dicotyledonous) as affected by kerosene type and concentration and plant features was determined. Tested plants formed three groups: more tolerant, less tolerant, and intolerant, in which relative germination was more than 70%, 30–70% and less than 30%, respectively. As parameters of soil phytotoxicity, effective kerosene concentrations (EC) causing germination depression of 10%, 25% and 50% were determined. EC values depended on the plant species and varied in a wide range of kerosene concentrations: 0.02–7.3% (EC_{10}), 0.05–8.1% (EC_{25}), and 0.2–12.7% (EC_{50}). The reported data on germination in soils contaminated by oil and petrochemicals were generalized. The comparison showed that at very high contamination levels (10 and 15%) kerosene was 1.3–1.6 times more phytotoxic than diesel fuel and 1.3–1.4 times more toxic than crude oil, and at low (1 and 2%) and medium (3 and 5%) levels the toxicity of these contaminants was close differing by a factor of 1.1–1.2. Tolerance of plants to soil contamination had a species-specific nature and, on the average, decreased in the following range of families: *Fabaceae* (germination decrease of 10–60% as compared to an uncontaminated control) > *Brassicaceae* (5–70%) > *Asteraceae* (25–95%) > *Poaceae* (10–100%). The monocotyledonous species tested were characterized as medium- and low-stable to contamination, whereas representatives of dicotyledonous plants were met in all groups of tolerance. Tested wild plants, contrary to reference data on oil toxicity, were more sensitive to kerosene than cultivated. No correlation was observed between degree of plant tolerance to kerosene and mass of seeds. The evidence indicates factors as structure and properties of testa, structure of germ, type of storage compounds, and type of seed germination (underground or aboveground) are more important.

1. Introduction

Petroleum hydrocarbons (PHCs) are constituents of engine fuels, industrial solvents and many other products and are the most widespread among the organic contaminants due to extensive current use of oil and petroleum products throughout the world. They are found in surface soils due to human activities, including spills during extraction, refining and transportation of oil and petroleum products, accidents at chemical and petrochemical enterprises (20–30 million t/year), presence in the atmosphere (50–90 million t/year) as a result of burning petroleum products, etc. (Panin, 2002).

After reaching the soil surface and then the aerated soil environment, PHCs degrade very slowly. PHCs accumulated in the upper soil layers significantly transform their physical–chemical and microbiological characteristics and usually depress germination and growth of plants, thus making soils phytotoxic (Salanitro, 2001). They also have direct toxic influence on plants when they contact plant tissues. However, plants respond to PHCs differently. Some of them may resist PHC contamination and some tolerant plants may be useful for cleaning up contaminated soils.

Data on the influence of PHCs on plant tolerance are scarce. Furthermore, the results are often inconsistent and poorly systematized (Breus and Larionova, 2006; Newman and Reynolds, 2004) because of differences in experimental conditions, i.e. greenhouse or field studies, different soil type and water regime, plant species and sorts, PHC classes and concentrations, duration of contamination, etc. Germination is the most widespread parameter used for estimating toxicity of PHC contaminated soils (Baud-Grasset et al., 1993; Chaîneau et al., 2003; Gong et al., 2001; Kireeva, 2003; Ogbo et al., 2010; Peng et al., 2009; Petukphov et al., 2000; Wang et al., 2001), plant tolerance to contamination (Gong et al., 2001; Kireeva, 2003; Tesar et al., 2002), and even plant phytoremediation activity (Dorn and Salanitro, 2000; Gaskin et al., 2008; Henner et al., 1999; Kummerova et al., 2008; Maila and Cloete, 2002; Mang et al., 2010). In some cases, germination dynamics is also considered as a characteristic of soil phytotoxicity (Gilyazov and Gaisin, 2003; Kireeva, 2003).

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