Influence of Dinitrophenol Herbicides on Microbial Activities in the Soil

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Dinitriphenol herbicides were first used about 50 years ago. These herbicides were found to uncouple oxidative phosphorylation and inhibit other processes /SIMON, 1953/.

The literature on the side-effects of these pesticides on soil microorganisms and their activities is vast. More than 200 research articles deal with the effects on non-target microorganisms, tested using pure cultures or soil under laboratory, greenhouse or field conditions. In the following, however, only the effects of doses relevant to field applications on important microbial processes are discussed.

Microbial biomass

As shown in Table 1, few articles describe the effects of these herbicides on microbial biomass. These results, in combination with investigations on biomass-related activities indicate, however, that marked inhibitions can be caused by field doses. Higher doses produced even greater effects. Changes within the soil biocoenosis cannot be excluded.

Carbon cycle

The substrate-induced and biomass-related short-term respiration was more or less inhibited depending on the test conditions. /Table 1/. Substrate turnover within the carbon mineralization process may be inhibited or stimulated under some conditions, however. Increased long-term respiration indicates mineralization of damaged or killed biomass. The inhibition of cellulose decomposition may also be modified by N release during mineralization of the microbial biomass.

Nitrogen cycle

In some cases ammonification /N mineralization/ was inhibited. More frequently, however, it was stimulated by the herbicides /Table 1/. As with the C cycle, this effect partly depends on the action on the biomass. Nitrification is generally a sensitive indicator of side-effects. In some cases, however, inhibition may be masked by increased NH_4^+ liberation from additionally mineralized humus or killed biomass. In these cases stimulation

Table 1

Influence of dinitrophenol herbicides /field relevant doses/ on non-target microbial activities in soil

Microbial activity	Herbicide: DNOC	DNBP	Dino-terb	Medino-terb*	References
CARBON CYCLE					
biomass		–			MALKOMES and WÖHLER /1983/; SCHUSTER /1987/
short-term respiration		–O+	–O	–O	MALKOMES /1984, 1989/; MALKOMES and WÖHLER /1983/
long-term resp. /–C/	– +			+	AMMON and JÄGGI /1981/; HICKISCH /1981/; MALKOMES /1984/
long-term resp. /+C/	–O+	–O+		O+	HAUKE-PACEWICZOWA /1971/; JENSEN /1965/; LEWIS et al. /1978/; MALKOMES /1984/
cellulose decomposition	O+	–O+		–O+	AMMON and JÄGGI /1981/; MALKOMES /1982/; SCHUSTER /1987/
NITROGEN CYCLE					
ammonification	O+	–O+		O+	LEWIS et al. /1978/; MALKOMES /1982, 1984/; MALKOMES and WÖHLER /1983/; VLASSAK and HEREMANS /1974/
nitrification	–O	–O+		O+	MALKOMES /1982, 1984/; MALKOMES and WÖHLER /1983/; SCHUSTER /1987/; VLASSAK and HEREMANS /1974/
denitrification		O			YEOMANS and BREMNER /1985/
N_2 fixation /asymb./	–O	–O			HAUKE-PACEWICZOWA /1971/; VLASSAK and HEREMANS /1974/
N_2 fixation /symb./		–O+			ALAA-ELDIN et al. /1981/; JOHNEN et al. /1979/
OTHER NUTRIENT CYCLES					
sulphur		O			LEWIS et al. /1978/
phosphorus	+	O			BELOV and TARLAPAN /1961/; LEWIS et al. /1978/
ENZYME ACTIVITIES					
catalase	O+	–O			PROTASOV /1970/; ZINCHENKO et al. /1969/
dehydrogenase	O	–O+	–O	–O	GOSTKOWSKA and FUCZAK /1981/; HAUKE-PACEWICZOWA /1971/; HICKISH /1981/; MALKOMES /1984, 1989/; MALKOMES and WÖHLER /1983/; SCHUSTER /1987/
urease	–O+	O+			GOSTKOWSKA and FUCZAK /1981/; STRYCKERS et al. /1976/; ZINCHENKO et al. /1969/; ZUBETS /1968/
protease	O				ZUBETS /1968/
phosphatase	O+	+	O		GOSTKOWSKA and FUCZAK /1981/; MALKOMES /1989/; STRYCKERS et al. /1976/; ZUBETS /1968/
invertase, saccharase	–O+	–O			VLASSAK and HEREMANS /1974/; ZINCHENKO et al. /1969/; ZUBETS /1968/
Formation/decomposition of complex substances					
straw decomposition		O		O	MALKOMES /1982/; MALKOMES and WÖHLER /1983/
soil structure	–				KAMPF /1968/

* medinoterb-acetate + propham; – = inhibition; O = no effect; + = stimulation; long-term respiration: +/–C = with or without organic substrate

occurs in spite of biocidal effects. Denitrification is known to be less sensitive to pesticides and this is also indicated in Table 1. Both asymbiotic and symbiotic N_2 fixation may be inhibited by these herbicides. In some cases this may result from direct damage to the host plant.

Other nutrient cycles

The few available data indicate only slight effects /Table 1/. As with the C and N cycles, however, liberation of nutrients from damaged or killed biomass can be expected.

Enzymatic activities

Dehydrogenase activity /TTC reduction/, a sensitive indicator of side-effects, was often inhibited by these herbicides /Table 1/. The other enzymes were less markedly affected or, in some cases, were stimulated. This stimulatory effect is probably linked to the increased formation of available nutrients by mineralization.

Formation and decomposition of complex substances

Only a small amount of information is available. Straw decomposition is generally not affected. Some reports also suggest that soil structure may be adversely affected.

Conclusions

Most publications on the side-effects of dinitrophenol herbicides refer to DNBP /dinoseb/. Also, most articles on the effects on microbial activities deal with the different forms of respiration measurements, with nitrification and dehydrogenase activity. The magnitude of inhibitory effects on sensitive indicators like short-term respiration and dehydrogenase activity may reach more than 40% and that of stimulations of the C and N mineralization more than 20%. Both of these effects may last for longer than 6 months under laboratory conditions. Data from field experiments suggest that these effects occur mostly in the upper soil layer, where they were less marked and lasted only 4 months. Nearly all side-effects were modified by numerous ecological factors. In sandy soils, for example, effects were often more pronounced. Amendments of soil with organic material /manure, etc./ may reduce some side-effects. Dinitrophenol herbicides are among the relatively few pesticides which are known to produce numerous side-effects. This is not surprising, as these herbicides also have fungicidal and insecticidal activity, which, in some cases, has been exploited in agricultural practice.

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