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Effects of Asulam on Some Microbial Activities of Three Soils

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Although the herbicide asulam, methyl [(4-aminophenyl) sulphonyl] carbamate, was discovered in 1961, very little has been published about its effects on soil micro-organisms. This is surprising as it is a widely used herbicide and although applied post-emergence some will reach the soil. It has been reported to have sulphonamide-like activity on common soil micro-organisms (ANON 1967). However, GROSSBARD (1970) showed that 500 ppm sulphanilamide incubated in soil had no inhibitory effect on CO_2 production and slightly increased counts of viable bacteria.

Previous work with asulam at the Weed Research Organization (WRO) has produced many inconclusive results. However, GROSSBARD & DAVIES (1976) reported that in one soil nitrification was inhibited by 5 ppm asulam. In contrast RATNAYAKE & AUDUS (1978) reported that asulam was of low toxicity to pure cultures of micro-organisms and in a perfusion system had little effect on nitrogen transformations in soil.

It is, therefore, pertinent to acquire further information on the effects of asulam on soil micro-organisms. The studies described here use three different soils and are based on the guidelines recommended by the U.S. ENVIRONMENTAL PROTECTION AGENCY (1978).

MATERIALS AND METHODS

Soils and herbicide

The soils used were an arable (I) and grassland (III) soil from the Weed Research Organization and an arable soil from East Anglia (II). Some of their characteristics are given in Table 1.

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Table 1

Soil characteristics

Soil classification	SOIL I Loamy sand	II Sandy loam	III Sandy loam
pH (in water)	6.2	6.1	5.3
Available P, µg P g^{-1} dry soil	23.3	52.5	19.7
Total N, %	0.09	0.28	0.40
Organic C, %	0.9	3.1	4.4
NH_4^+-N, µg N g^{-1} dry soil	0.85	1.91	2.45
NO_3^--N, µg N g^{-1} dry soil	2.69	40.0	7.85
CEC, mEq/100g	16	37	41
Clay, %	14	16	15
Silt, %	15	25	17
Fine sand, %	35	47	40
Coarse sand, %	36	12	27
Field capacity, % H_2O	19	29	32

Soil II was very dry and after sieving through a 5 mm sieve was put in large plant pots, watered and kept in a greenhouse for 2 weeks to stimulate its microbial population. The two soils from WRO were very wet when collected and were thus partially air dried, sieved and put into plant pots in the greenhouse and kept moist for 2 weeks. The soils were then treated with herbicide.

Asulam was applied to the soils as 'Asulox', active ingredient 40% w/v methyl [(4-aminophenyl) sulphonyl] carbamate (as Na salt). The soil was spread evenly over an aluminium tray and herbicide applied using a pot sprayer (GROSSBARD & WINGFIELD, 1975) at rates calculated to give concentrations of 16 and 160 ppm asulam on a dry weight basis. These concentrations are equivalent to 2.5 and 25 kg ha^{-1} evenly distributed in the top 1 cm of soil. In practice, of course, even the lowest concentration is unlikely to be achieved in soil, other than in isolated spots, as much of the herbicide will be retained on the crop canopy. The moisture content of the treated and control soils was adjusted to 80% of field capacity by spraying with water using the pot sprayer. The soil from each treatment was spread on a sheet of polyethylene and thoroughly mixed by hand. It was then bagged and kept at room temperature until the experiment was set up next day.

Soil incubation

Respiration of asulam treated and untreated soils was measured as described by GREAVES et al. (1978).

In order to investigate the breakdown of cellulose, a further four 100 g replicates of control and treated (160 ppm asulam) soils I and III were thoroughly mixed with 1g CC41 cellulose powder (Whatman Labsales, Maidstone, Kent). The moisture content of soils was adjusted every 6 weeks. CO_2 output from these soils was measured as described by GREAVES et al. (1978).

For all other tests, four replicates of approximately 200 g soil from each treatment were put in polyethylene-lined plant pots and incubated at $19 \pm 2^{o}C$. Sets of samples for each sampling date were incubated inside large polyethylene bags to reduce moisture losses. The moisture content of the soils was adjusted when moisture loss had reached approximately 2%.

Sampling

One set of the pots, described above, were taken at each sample date and tested for phosphatase, dehydrogenase and urease activity. Sub-samples were dried for available-phosphate analysis and the remaining soil was stored at $-15^{o}C$ until analysed for mineral-nitrogen.

Full details of all the methods used are given by GREAVES et al. (1978).

RESULTS

No significant accumulations of NH_4^+-N were observed in either control or treated soils but total mineral-nitrogen generally increased in both, indicating that nitrification was not inhibited. Apart from an increase caused by 160 ppm asulam in soil I, which lasted for 8 weeks, the herbicide generally caused only small effects on total mineral-nitrogen ($< \pm 20\%$). Since soil I was very low in mineral-nitrogen none of these effects is considered to be important.

Effects of asulam on CO_2 output of unamended soils I and II were generally small and variable, but in soil III both concentrations of herbicide reduced output (Fig. 1), the effect being very noticeable at 160 ppm throughout the incubation period.

When 1% cellulose was added to soils I and III, CO_2 output was much greater than from unamended soil and the effects of the herbicide were modified (Fig. 2). In control soils, a surge in output occurred after 2 weeks in soil III, but not until after 8 weeks in soil I. In soil I, 160 ppm asulam eliminated the surge in CO_2 output which occurred in control soil whereas in soil III it delayed its appearance for 6 weeks. Apart from the period of the surge in soil III, 160 ppm asulam reduced CO_2 output of both cellulose amended soils compared with similarly amended controls. Asulam reduced total CO_2 output, over the

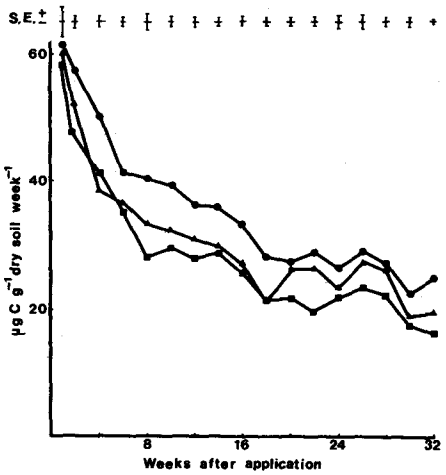

Fig. 1. The effect of asulam on CO_2 output of soil III. ●, control; ▲, 16ppm; ■, 160 ppm.

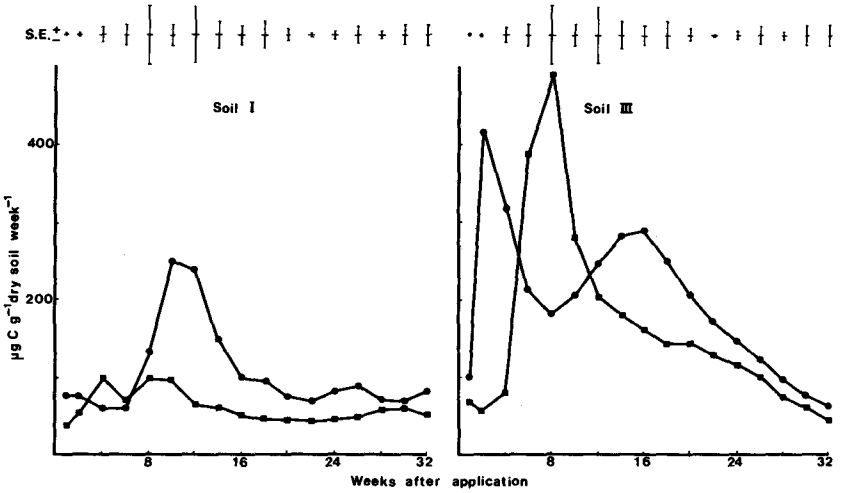

Fig. 2. The effect of asulam on CO_2 output of soil amended with 1% cellulose. ●, control; ■, 160 ppm.

whole experimental period, of cellulose amended soil I by 40% and soil III by 15% compared to similarly amended control soil.

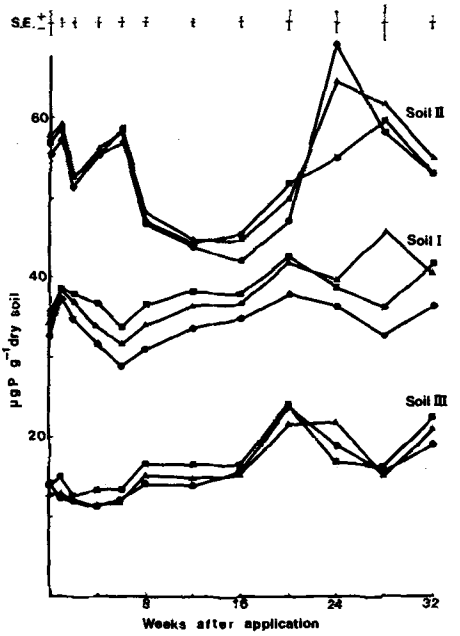

Fig. 3. The effect of asulam on available-P in soil. ●, control; ▲, 16 ppm; ■, 160 ppm.

The largest effects on available phosphate levels were in soil I (Fig. 3) where both concentrations of herbicide increased phosphate throughout the experimental period. In soil III, 160 ppm asulam caused a slight increase in available phosphate for much of the experiment, but in soil II, which had the highest available-P level, effects were only observed at isolated sample dates.

Soil I consistently had the lowest enzyme activities (Figs. 4, 5, 6). Asulam had very little effect on phosphatase activity (Fig. 4) or dehydrogenase activity (Fig. 5) in this soil, but urease activity was increased slightly from week 12 onwards (Fig. 6). In soil II, although dehydrogenase activity was reduced similarly to in soil III (Fig. 5), phosphatase activity was slightly increased on some occasions (Fig. 4). In soil II urease activity was reduced by 160 ppm asulam from weeks 16 to 24 (Fig. 6).

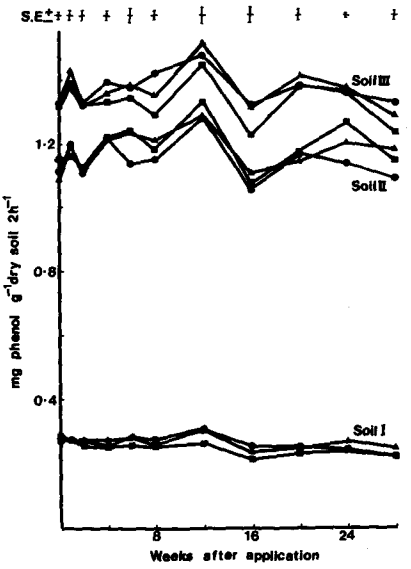

Fig. 4. The effect of asulam on phosphatase activity of soil. ●, control; ▲, 16 ppm; ■, 160 ppm.

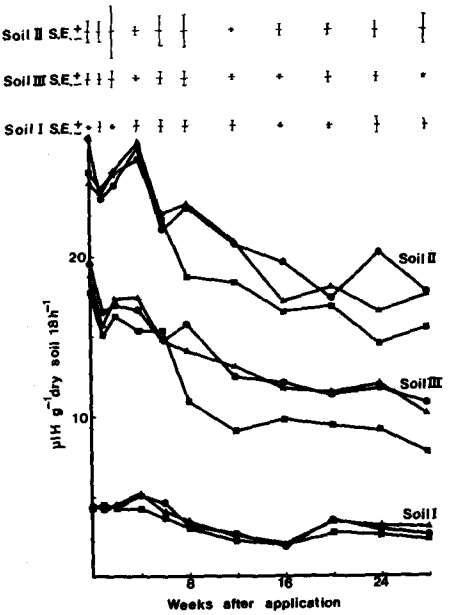

Fig. 5. The effect of asulam on dehydrogenase activity of soil. ●, control; ▲, 16ppm; ■, 160 ppm.

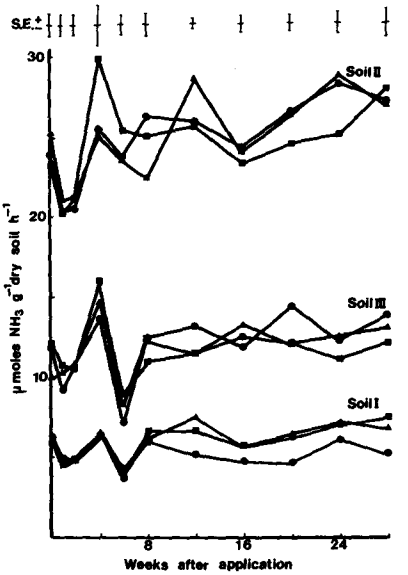

Fig. 6. The effect of asulam on urease activity of soil. ●, control; ▲, 16 ppm; ■, 160 ppm.

DISCUSSION

The results reported here show that the three soils differed in their activities and, sometimes, in their response to asulam. Usually the level of activity was in the order soil II > soil III > soil I and reflects the initial nutrient status of these soils (Table 1). Response to the herbicide, however, did not show an overall correlation with soil nutrient level.

Very few effects occurred with the 16 ppm concentration of asulam, which might result from normal field rates, and no inhibition of nitrification occurred at either concentration. This contrasts with the results reported by GROSSBARD & DAVIES (1976) who showed inhibition of nitrification in one soil with 5 ppm asulam.

At the higher concentration more frequent effects occurred, but these were both inhibitory and stimulatory and the same effects did not occur in all three soils. Variation in effects of asulam have previously been reported by GROSSBARD (1970).

The most striking effect observed was the delay in the surge and the overall reduction of CO_2 output caused by 160 ppm asulam in soil to which 1% cellulose had been added. This confirms the inhibition of cellulose breakdown by asulam, in these soils, reported by WINGFIELD (1980). A reduction in CO_2 output was also observed with both concentrations of asulam in soil III without added cellulose, but this effect did not occur in the other soils. This is possibly an effect of the herbicide on organic matter breakdown as this soil had the highest organic carbon content (Table 1) and therefore may have contained more material which would normally degrade more rapidly. This hypothesis is supported by the fact that CO_2 output of control soil III over the 32 week test period was much greater than that of soils I and II.

The reduction in dehydrogenase activity caused by 160 ppm asulam in soil III correlates with the reduction in CO_2 output of this soil, but dehydrogenase activity was also reduced by 160 ppm asulam in soil II, although CO_2 output of this soil was not affected. Similarly, soil I showed the expected inverse correlation between phosphatase activity and available-P, the enzyme activity being lowest in 160 ppm asulam treated soil while this treatment had the highest available-P. It is also noteworthy that soil I contained more available-P than soil III, but the phosphatase activity was the converse of this. Again, however, this inverse correlation was not observed with soil II. No correlations were observed between urease activity and the mineral-nitrogen measurements made.

From the results obtained in this work it would appear that the low concentration of asulam, which may be characteristic of normal field applications, is unlikely to have effects of

agronomic importance. In some soils the higher concentration of the herbicide, which could occur in isolated spots in the field, especially following misapplication might have effects which could be of agronomic importance, as, although not as large as natural variation in the field (MARSH, 1978), they are frequently more persistent.

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