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EFFECT ON NITROGEN MINERALIZATION OF FOUR SOIL-APPLIED CHEMICALS USED IN TOBACCO PRODUCTION

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SUMMARY

Three pot trials were conducted during the 1973–74 season to assess whether four soil-applied chemicals used in the commercial production of flue-cured tobacco affected the process of nitrogen mineralization.

Two nematocides, EDB and fenamiphos, and two herbicides, benfluralin and nitralin, were studied.

The chemicals were applied at rates equivalent to those recommended for field use. Field incorporation techniques were simulated.

EDB was the only chemical to exert an inhibitory effect on nitrogen mineralization. The process was inhibited at the first stage of nitrification, causing ammonium to accumulate.

I. INTRODUCTION

Studies of nitrogen mineralization in soil used for tobacco growing in the Mareeba (Goodman 1965) and Moreton districts (Ferguson and Green 1976) suggest that soil nitrogen supplies a significant proportion of the plant nitrogen requirements.

Time of absorption of nitrogen and the form in which it is absorbed are important factors in the production of flue-cured tobacco. To achieve the proper maturity in the cured product, it is essential that the rate of nitrogen absorption decrease rather rapidly during the latter portion of the growth period (McCants and Woltz 1967).

The form of nitrogen absorbed influences the growth and development of the plant. In sand and solution cultures various reductions in the growth rate of tobacco plants have been recorded when ammonium has been the sole or dominant form of nitrogen supplied (Gilmore 1953; McEvoy 1946, 1957). Several field investigations have also been conducted (Tisdale 1952; Ward *et al.* 1973; Gous, Terrill and Kroontje 1971). The results of these investigations invariably depend on the suitability of the test site for biological activity. For example, Ward *et al.* (1973) found little difference in the field and quality index of tobacco grown in north Queensland with different sources of inorganic nitrogen fertilizer. They concluded that nitrification of the applied ammonium accounted for the general similarity in response. In this study, soil fumigation with EDB had no effect on the yield and leaf quality index of the cured tobacco. McCants, Skogley and Woltz (1959) found a similar result with EDB. However, when methyl bromide and DD (dichloropropane and dichloropropene) were used, the tobacco was observed to respond unfavourably to applied ammonium when compared with nitrate. They found that inhibition of nitrification resulted in greater ammonium, nitrogen and halogen concentrations in the leaves when ammonium was the sole form of nitrogen applied. These higher concentrations were associated with certain leaf abnormalities and stunting of the plants. EDB was found to have less effect on nitrification than the other two chemicals. Presumably more of the applied ammonium was converted to nitrate and taken up by the plant in this form.

Other workers have also found that EDB has a lesser effect on nitrification than other commonly used soil fumigants (Wensley 1953; Koike 1961; Good and Carter 1965). Tillett (1964) on the other hand, found that EDB had no effect on this process.

The studies reported in this paper were conducted during the 1973–74 season to assess whether four soil-applied chemicals used in the commercial production of flue-cured tobacco, affected the process of nitrogen mineralization.

Two nematocides, EDB and fenamiphos and two herbicides, benfluralin and nitralin, were studied. To our knowledge no investigation of the effect of the latter three chemicals on nitrogen mineralization has previously been reported.

II. MATERIALS AND METHOD

Treatments

Five treatments were compared in each of the three trials. They were Control, EDB (1,2—dibromoethane—kerosene base) 80·28 kg a.i. ha^{-1}, fenamiphos (ethyl 4-(methylthio)-m-tolyl isopropyl phosphoramidate) 9·81 kg a.i. ha^{-1}, Benfluralin (N-butyl-N ethyl-2, 6-dinitro-4-trifluoromethyl aniline) 1·33 kg a.i. ha^{-1} and Nitralin (4-(methyl sulphonyl)-2, 6-dinitro-N, N-dipropylaniline) 0·84 kg a.i. ha^{-1}.

Method of Application

A square fibre-glass pot 0·813 m^2 in surface area and 30 cm deep constituted a treatment unit in each experiment.

The recommended field incorporation technique was simulated for each chemical. For EDB, a 30-cm grid was placed over the surface of each pot and an equal volume of chemical applied at each point on the grid to a depth of 10 cm. The remaining three chemicals were applied to the soil surface by a hand sprayer.

Irrespective of treatment, the soil of each pot was worked thoroughly to a depth of 10 cm immediately after treatment application and then lightly tamped.

Experimental Design

The five treatments were arranged in a latin square design in each experiment.

Experiments I and III were designed to determine if the chemicals affected either the ammonification or the nitrification process. The blood and bone fertilizer used in these experiments (table 1) was mixed uniformly throughout the soil in each pot with the aid of a concrete mixer before the treatments were applied.

TABLE 1

GENERAL TRIAL DATA

Experiment Number	Duration (Weeks)	Commencement Date	Form and Rate of Mineralizable Material
I	5	26 Sep 73	Blood and bone fertilizer 2 263 kg N ha^{-1}
II	4	14 Nov 73	0·3 M $(NH_4)_2 SO_4$ solution 2 375 kg N ha^{-1}
III	6	3 Apr 74	Blood and bone fertilizer 2 263 kg N ha^{-1}

Experiment II was designed to determine if the chemicals affected any stage of the nitrification process. The mineralizable material used was 0·3 M $(NH_4)_2$ SO_4 solution and 23 *l* of this was applied to each pot. The resultant leachate was collected and re-applied to the soil surface. This process was repeated many times over several days.

The approximate dry weight of soil added to each pot in the three experiments was 120 kg.

The experiments were situated on adjacent sites. Soil type was a yellow mottled acid leached structured earth (Gn. 3·74; Northcote 1974). The soil contained 2·0% carbon and 0·12% total nitrogen before the experiments were started. Organic carbon was determined by the Walkley-Black method (Allison 1965).

Factors Affecting Mineralization

The soil temperature, pH and moisture ranges at which ammonification is operative have been found to be much wider than the ranges for nitrification (Justice and Smith 1962; Cornfield 1953; Robinson 1957). In experiment II, greater emphasis was placed on maintaining two of these factors at levels suitable for nitrification. Soil pH was increased by the addition of lime at the rate of 17·6 t ha^{-1} and soil moisture was maintained within a range close to field capacity by watering at regular intervals. Although soil temperature could not be controlled, the commencement date for experiment II was chosen to coincide with warm night temperatures.

In experiments I and III, the soil pH of the chosen sites was not altered and soil moisture was allowed to vary over a wider range. Soil temperatures were also lower during these experiments, particularly during experiment III.

The levels of these factors recorded are presented in table 2.

TABLE 2

FACTORS AFFECTING MINERALIZATION

Experiment Number	PH at Commencement	Minimum Soil Moisture Range (% Field Capacity)	Soil Temperature (depth 23 cm)	
			Mean Maximum (°C)	Mean Minimum (°C)
I	5·3	50	34	20
II	7·0	77	39	21
III	5·3	40	26	14

Soil temperatures were monitored by a continuous soil temperature recorder. Soil moisture at each site varied from the average minimum value presented in table 2 to field capacity. These were determined weekly and the quantity of water required to bring each pot to field capacity calculated and applied. The presence of leachate from a pot could be recorded following watering and loss of nitrogen in the leachate allowed for by calculation. This occurred on only one occasion.

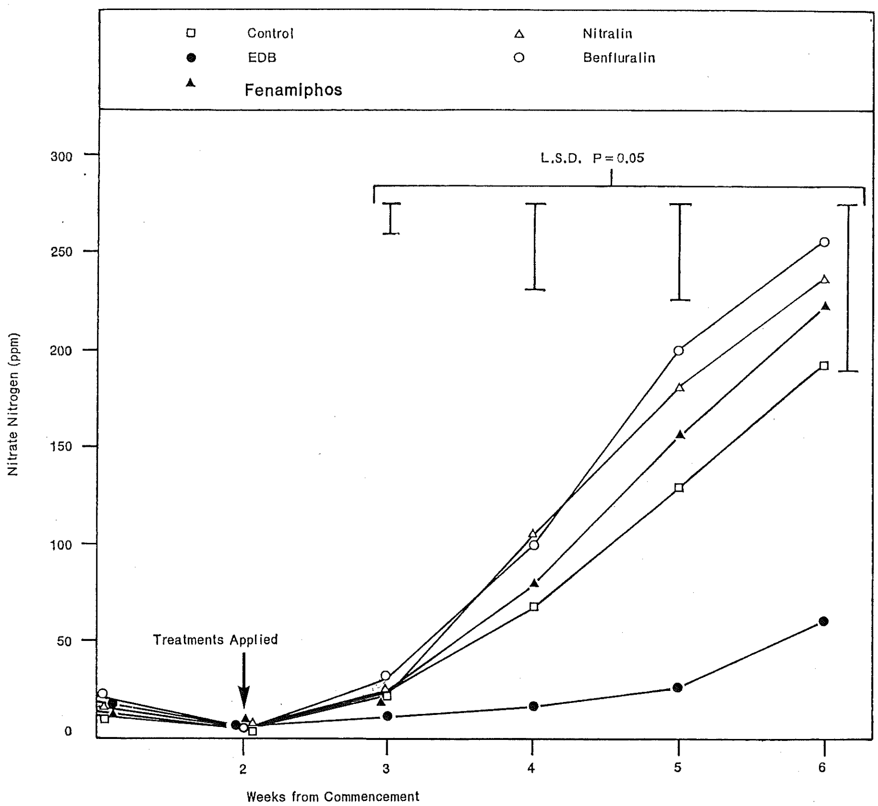


Figure 1.—Effect of treatment on net nitrate nitrogen production in experiment I.

It was assumed that denitrification losses were negligible because:

1. a very efficient drainage system was achieved in each pot by placing a layer of 7·5 cm of coarse sand over 2·5 cm of washed river gravel; and

2. the soil in each pot was of a very friable nature following the thorough mixing it received at the commencement of each experiment.

Soil Sampling

Pots were sampled at weekly intervals. Six 2·5 cm soil cores were taken to a depth of 15 cm from quadrats which had been selected at random. The cores were passed through a 3 mm sieve and mixed thoroughly. A sub-sample was taken for moisture determination and the remaining sample transported to the laboratory under cool storage.

Treatments were applied 1 week after commencing each experiment.

Chemical Analysis

Ammonium and nitrate concentrations were determined by Orion electrodes. The former was determined directly on a 1:5 (wt:vol) 2N KCl extract and the latter on a 1:5 aqueous extract.

Nitrate concentrations were determined colorimetrically by the modified Griess—Ilosvay method (Bremner 1965).

Soil pH was determined by a glass electrode on a 1:2·5 soil water suspension.

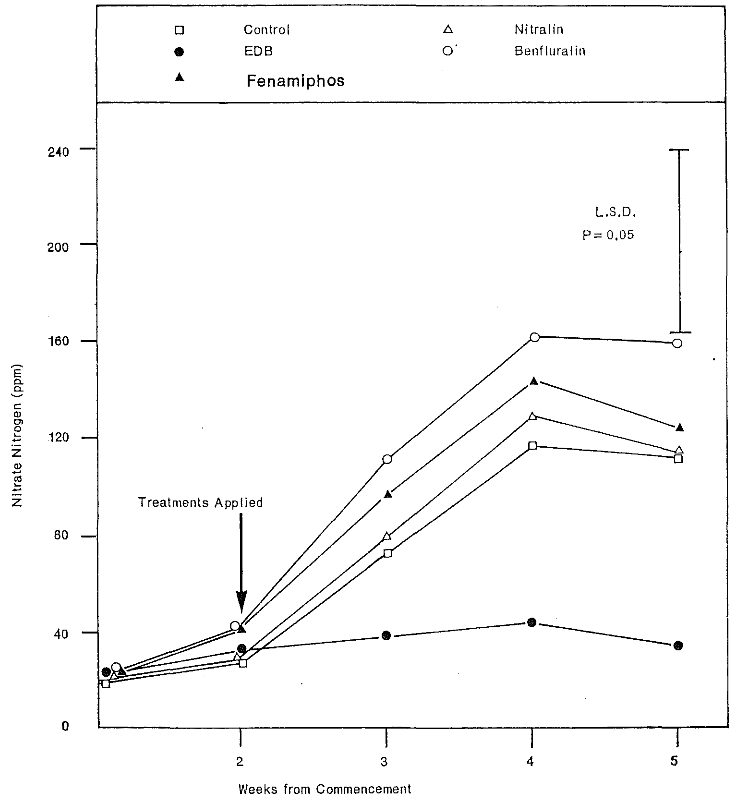


Figure 2.—Effect of treatment on net nitrate nitrogen production in experiment II.

III. RESULTS

The results showing the effect of treatment on nitrogen transformations relative to the control treatment are presented in figures 1 to 6.

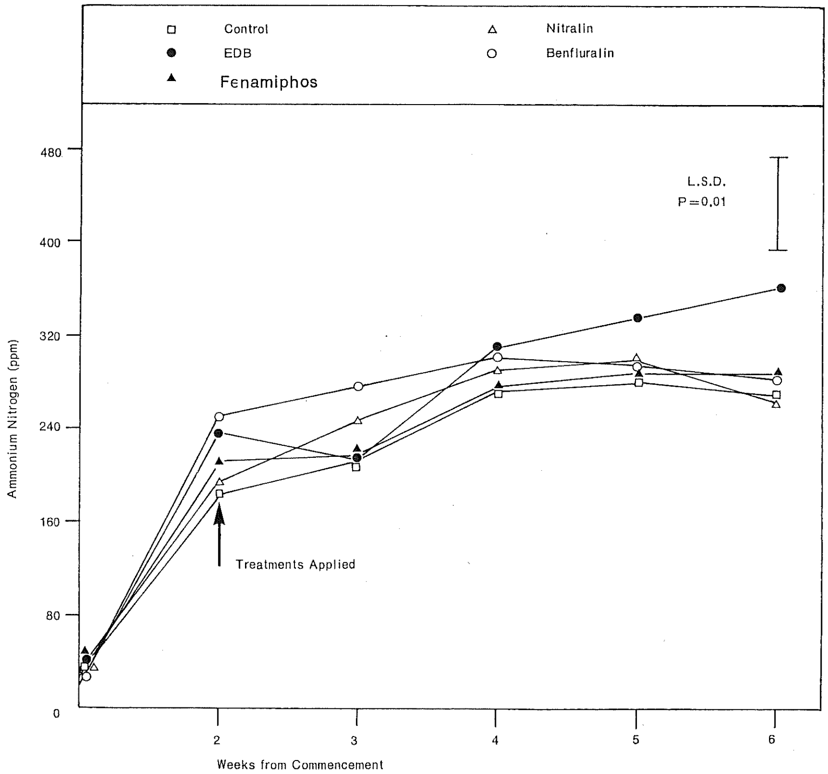


Figure 3.—Effect of treatment on net ammonium nitrogen production in experiment I.

Nitrate nitrogen levels were significantly lower with EDB treatment than the control in both experiments I and II ($p = 0 \cdot 05$; figures 1 and 2). The remaining three treatments were not significantly different in either experiment.

Ammonium nitrogen was significantly higher with EDB treatment than the control at 6 weeks in experiment I ($p = 0 \cdot 01$, figure 3). However, no similar result was found in experiment III (figure 4).

Nitrite and nitrate concentrations were zero for the weeks preceding week 5 in experiment III. Only low levels were recorded subsequently. This trial experienced cool temperatures relative to those found to be conducive to rapid nitrification (table 2; Justice and Smith 1962; Campbell and Biederbeck 1972). The results obtained appear to be related to this factor. Partial suppression of nitrification in experiment III would confound any obvious treatment effect on this process since ammonium would accumulate irrespective of treatment.

Net mineral nitrogen production with EDB did not vary significantly from that of the control treatment in experiment I (figure 5).

The inhibitory effect of EDB on nitrate production relative to the control is shown in figure 6. This difference was not found to be significant however.

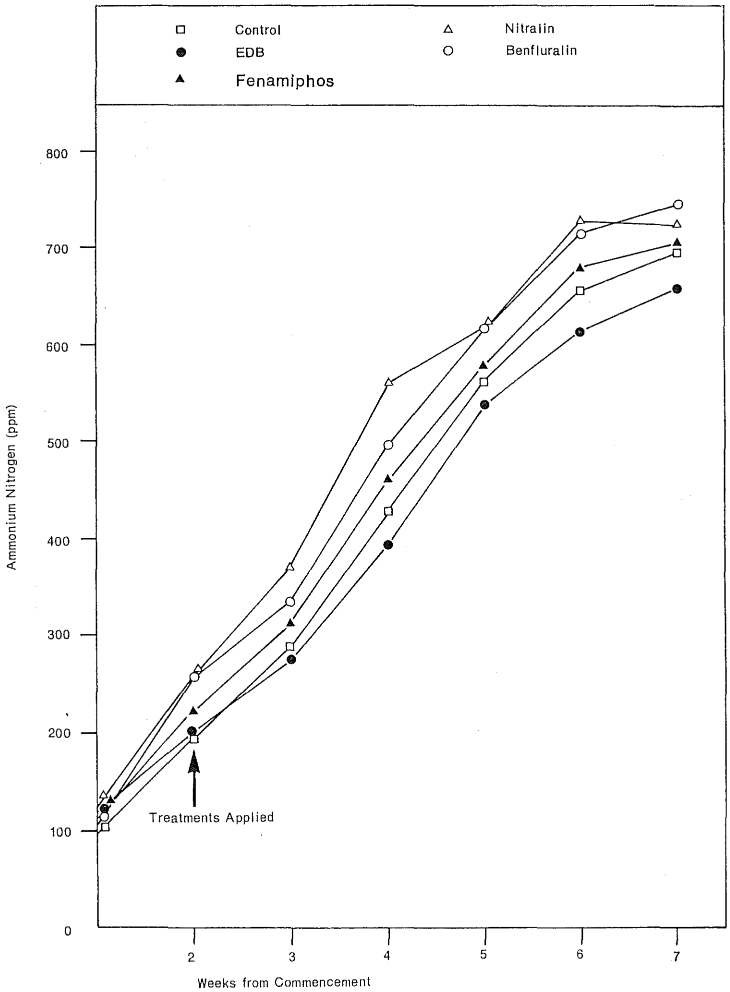


Figure 4.—Effect of treatment on net ammonium nitrogen production in experiment III.

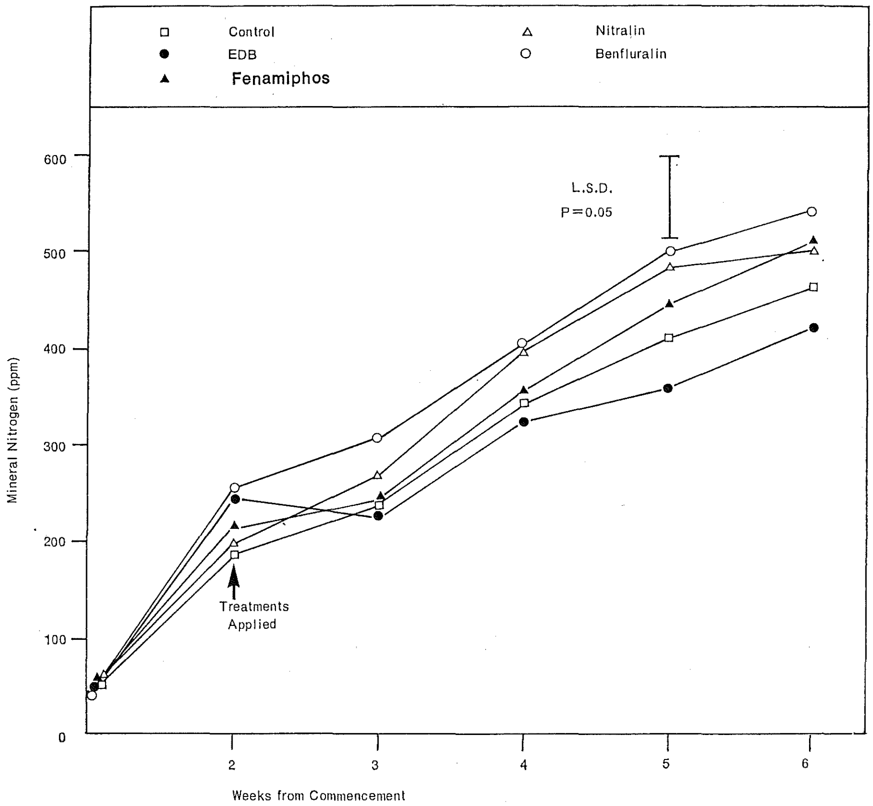


Figure 5.—Effect of treatment on net mineral nitrogen production in experiment I.

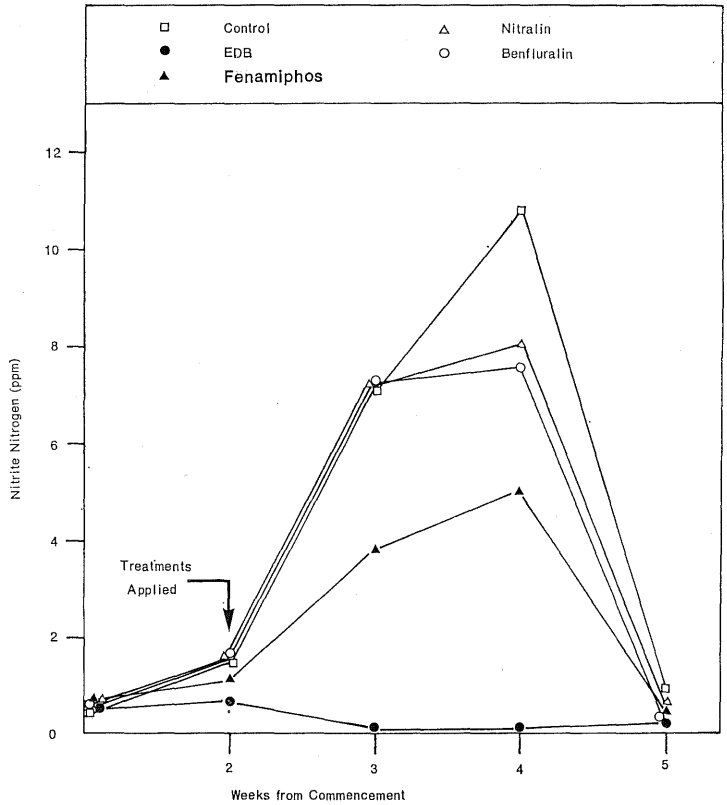
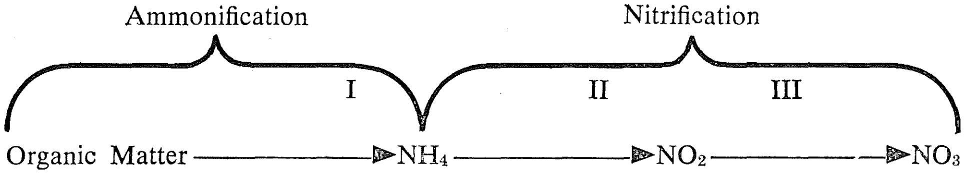


Figure 6.—Effect of treatment on net nitrate nitrogen production in experiment II.

IV. DISCUSSION

The process of nitrogen mineralization in the soil can be represented diagrammatically as follows—



Previous workers have found that when inhibition of the process occurs at Stage II, an accumulation of ammonium occurs followed by a subsequent reduction in the concentrations of nitrate and nitrite relative to a control (Cornfield 1953; Robinson 1957; McCants, Skogley and Woltz 1959). Similarly when inhibition of the process occurs at Stage III, nitrite accumulates. (Lees and Quastel 1945; Gasser 1970).

In these studies, it was assumed that if inhibition was to occur at Stage I, the concentrations of all three ions would decrease relative to those of the control treatment.

The results presented in figures 1 to 6 were interpreted on this basis. They show that EDB exerted an inhibitory effect on the mineralization process. This occurred at Stage II.

The inhibition was characterised by an accumulation of ammonium (figure 3) and a reduction in nitrate (figures 1 and 2) and nitrite (figure 6) relative to the control. Net mineral nitrogen production was not significantly different (figure 5). This result is in keeping with that generally attributed to EDB (Wensley 1953; Koike 1961; Good and Carter 1965).

Fenamiphos, nitralin and benfluralin did not inhibit any stage of the mineralization process. With these treatments, ammonium and nitrate nitrogen levels were not significantly different from the control in each experiment. However, some enhancement in the rate of these processes appears to have occurred. For example, nitrate (figures 1 and 2) ammonium (figures 3 and 4) and mineral (figure 5) nitrogen concentrations were all consistently greater than the control for these three treatments. On one occasion in experiment I (figure 5) this difference was significant for the benfluralin treatment.

It is concluded from these results that no inhibition of the mineralization processes will occur from the use of these three chemicals at rates recommended for field use. Tobacco growers should be aware of the inhibitory effect of EDB on nitrification when contemplating ammonium as the sole form of applied nitrogen.

V. ACKNOWLEDGEMENTS

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