Evaluation of the effect of two corn herbicides on nitrification in soils

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Abstract

Two corn herbicides commonly in use in Nigeria namely cyanazine: 2/(4-chloro-6-(ethylamino)-s-triazine-2-yl) amino -2-/ methylpropionitrite and atrazine: 2-chloro-4-(ethylamino)-6-(isopropylamino)-s- triazine were evaluated under greenhouse conditions to assess their effects on nitrification in soils at 3.0 and 6.0-kg/ha a.i. For the two soils used and the two herbicides, there was no evidence that the application of the herbicides at any of the rates inhibited nitrification irrespective of whether the soils were cropped or uncropped. In fact, there was a slight enhancement of nitrification. If this is a true trend under field conditions, it could suggest that the use of these herbicide under Nigerian conditions might be serving a dual purpose of controlling the weeds and promoting nitrification in soils.

Introduction

Of recent the use of herbicides is attracting a lot of attention by researchers. Institutes and the various Ministries of Agriculture in the country are making use of herbicides without ample evaluation of their effects on the biochemical and microbiological balance in the soils, in as much as the herbicides are able to control the weeds.

The addition to the soil of any potentially toxic substance constitutes a serious threat to the dynamic and delicate equilibrum which exists between the fertility of the soil and the various biochemical activities of microorganisms. One of such delicate processes that can be easily upset by the use of these foreign agents in soils and aquatic systems is nitrification (Alexander, 1977).

The two-way conversion of $NH4^+$-N to NO_3-N is mainly carried out by a group of chemolitotrophic organisms belonging to the genera *Nitrosomonas* and *Nitrobacter.*

Otten *et al.*, (1957) reported that the chlorinated aliphatic acid herbicides were quite toxic to the nitrifying bacteria and that the chlorinated phenols are moderately toxic. In the same experiments they treated 50g samples of soil to which ammonium phosphate had been added with chloropropham (Isopropyl-m-chlorocarbanilate) equivalent to 4.48 -8.96kgha a.i. and noted a reduction in the nitrate nitrogen. Other workers like Stapp and Bucksteeg and Newan and Downing as quoted by Andus (1976) also observed the inhibitory effects of different herbicides on soil nitrification. However, it is possible that the degree of inhibition would be in direct proportion to the concentration of the herbicide used especially at concentrations beyond the recommended rates in soils with low organic matter contents (Mitchel, 1968).

At the other extreme are workers who have observed an enhancement of nitrification by herbicide treatments. Tulabaev and Asinbegov (quoted by Andus, 1976) found that sixty days after treatment of a field of maize with simazine (2-chloro-4, 6-bis(ethylamino)-s-triazine) and atrazine the quantity of nitrate increased from 31% to 39% and from 37% to 48% respectively.

Under Nigeria conditions, Amakiri (1976) added three phenyl - urea herbicides ranging in concentration from 0.56 to 4.48kg/ha to 3-kg soils which were then planted to legumes a week after application. She noticed that during the first planting, there was a depression of nitrification in cowpea *Vigna unguiculata* (L.)(Walp) pots but enhancement in *Centrosema* pots. At the second planting however, both cowpea and *Centrosema* pots exhibited enhancement at the lower rates of the herbicides previously applied. There is no doubt that some of the contradictory results obtained up-to-date are a reflection of the different rates of application and different environmental factors. The contradiction could also be due in part to the content of organic matter in these soils since it is well known that the soil organic matter plays an important part in herbicide absorption thereby rendering it less effective biologically (Nearpass, 1965; Lambert *et al;* 1965; Adams, 1966; Upchurch and Muson; 1962).

The purpose of this investigation is to evaluate the effects of two commonly used corn herbicides on the process of ammonification and nitrification in soils in order to assess their values in weed control programmes.

Materials and methods

Materials

Two soil types varying in their history of cultivation and ecology were obtained from the University of Ife Research Farm. The first soil type (1) was obtained from a plot which had been continuously planted to maize for about three years and the second soil type (2) was from a land freshly opened from fallow of about ten years duration. The two soils were air-dried and sieved to pass through 2-mm sieve to remove large organic debris and roots. Two commonly used corn herbicides namely: cyanazine and atrazine were used. Both atrazine (80w) and cyanazine (50w) were used at the recommended rates and at double the recommended rates viz. 3 and 6-kg/ha a.i. The recommended rate is referred to as the low rate while double the recommended rate is the high rate. Corn *(Zea mays* var. Western yellow) was used as the test crop.

Methods

Five kg. of each soil was weighed into plastic buckets with two holes at the bottom of each bucket plugged with cotton wool. The water holding capacity of the soils had earlier been determined. Water solutions of these herbicides were then added to the soils spread on a plastic sheet and mixed thoroughly. 300-ml of distilled water was also mixed with each soil.

There were six pots per treatment. All the treatments were then arranged in a randomized block design on the laboratory bench. Three of the pots of each treatment were cropped to maize (2 grains per pot) immediately after the herbicide application and the remaining three pots were left uncropped. Six pots served as control for each soil without herbicide treatments but three of the pots were planted to maize and the other three unplanted. The initial weights of the pots were taken as the basis for subsequent water additions. Soils subsamples were taken on the first day for laboratory analysis and thereafter at weekly intervals for the duration of the experiment.

The exchangeable ammonium and nitrite + nitrate were determined on samples which had been air-dried under laboratory conditions by the method of Bremner and Keeney (1965). The amount of ammonium nitrogen after distillation was determined by titrating with 0.007 *N* Sulphuric acid from a micro-burette.

The organic matter in the soils was determined by the chromic acid digestion method (Walkley and Black, 1934). The mechanical analysis of the soils showed that soils type 1 has 19 percent clay, 60 percent soils and 21 percent sand. Soil type 2 is made up of 10.2 percent clay 0.4 percent silt and 89.4 percent sand.

Results

The first soil (1) is of silt loam in texture and has an initial PH of 7.9 in water and 6.7 in 0.0 1*M* $CaCl_2$. The initial organic matter content was 2.8% and the initial NH4-N and (NO_2+ NO_3)-N were 27 and 29 ug/g soil respectively. The second soil is sandy loam and had an initial pH of 7.30 and 6.65 in water and $CaCl_2$ respectively. The initial organic matter was 4.0% and the NH_4 -N and the (NO_2 + NO_3)-N were 35 and 37 ug/g soil.

TABLE 1: THE EFFECT OF APPLICATION OF ATRAZINE ON AMMONIFICATION AND NITRIFICATION IN SOIL 1.

Time	Rate	Cropped		Uncropped	
		NH_4 -N	(NO_2 + NO_3)-N	NH_4-N	(NO_2 + NO_3)-N
Wks		ug/g soil			
1	0	34.	54.	42.	45.
	high	37.	57.	44.	53.
	low	37.	59.	33.	54.
2	0	38.	43.	39.	51.
	high	32.	47.	37.	50.
	low	35.	43.	35.	51.
3	O	30.	45.	28.	40.
	high	29.	39.	30.	49.
	low	28.	41.	32.	47.
4	O	30.	34.	32.	35.
	high	31.	36.	31.	51.
	low	34.	30.	48.	56.
5	O	35.	31.	34.	52.
	high	36.	34.	40.	55.
	low	43.	34.	48	58.
6	O	66.	50	53.	76.
	high	63.	54.	56.	77.
	low	55.	48.	55.	82.
7	O	34.	32.	32.	88.
	high	34.	38.	35.	105
	low	35.	34.	35.	84.
8	O	43.	42.	48.	110.
	high	42.	41.	47	112.
	low	43.	34.	37.	96.

It is important to note that throughout the duration of the experiment, no weeds were evident in the treated pots (low and high levels of the two herbicides) whereas the controls were almost overgrown with weeds.

In the first soil during the first five weeks there was a slight decrease, especially in the cropped pots, in the inorganic nitrogen content of the soil irrespective of whether atrazine or cyanazine was the applied herbicide. By the end of sixth week, there was a significant increase (p 0.05) in inorganic nitrogen which dropped slightly at the end of the 7th and 8th weeks (Tables 1, 2, 5.).

It is interesting to note that there was no significant difference (p 0.05) in the inorganic N content between the herbicide treated pots and the control irrespective of whether cyanazine or atrazine was the applied herbicide and irrespective of whether the soil was cropped or uncropped. Also, there was no significant difference (p 0.05) in the levels of inorganic N between the high and low levels of the two herbicides irrespective of whether the soil was cropped or not.

TABLE 2: EFFECT OF CYANAZINE ON AMMONIFICATION NITRIFICATION IN SOIL 1

Time	Rate	Cropped		Uncropped	
Wks.		NH4-N	$(NO_2 + NO_3)$-N	NH_4-N	$(NO_2 + NO_3)$-N
			ug/g soil		
	O	34.	54.	42.	45.
1	high	33.	55.	35.	54.
	low	32.	55.	41.	53.
	O	38.	43.	39.	51.
2	high	38.	45.	39.	48.
	low	33.	47.	36.	51.
	O	30.	45.	38.	40.
3	high	30.	55.	37.	48.
	low	32.	36.	31.	59.
	O	30.	34.	32.	35.
4	high	41.	31.	37.	53.
	low	36.	24.	43.	37.
	O	35.	27.	34.	52.
5	high	38.	32.	49.	59.
	low	36.	24.	43.	37.
	O	46.	50.	53.	56.
6	high	44.	52.	56.	69.
	low	41.	43.	54.	48.
	O	34.	38.	32.	68.
7	high	36.	32.	38.	71.
	low	37.	36.	37.	61.
	O	43.	42.	48.	70.
8	high	42.	32	45.	66.
	low	47.	32	46.	63.

As expected there was a significant difference in the amount of extractable ammonium - N and (nitrite + nitrate)-N between the cropped and uncropped soils, due to plant uptake of inorganic N in the cropped pots but as far as the behaviour of the herbicides are concerned, the fact that some pots were cropped did not affect the behaviour of the herbicides. Also irrespective of whether atrazine or cyanazine was applied, there was no difference in the extractable inorganic nitrogen during the 8-weeks duration of the experiment.

For the second soil (Tables 3, 4, 5), the same trends that were found in the case of the first soil were evident. This soil showed an increased mineralization almost throughout the duration of the experiment irrespective of whether it was cropped or not cropped, although the increase in the cropped treatments appeared less dramatic than the uncropped soils due to plant uptake.

TABLE 3: EFFECT OF APPLICATION OF ATRAZINE ON AMMONIFICATION AND NITRIFICATION IN SOIL 2

Time Wks.	Rate	Cropped		Uncropped	
		NH_4-N	$(NO_2 + NO_3)$-N	NH_4-N	$(NO_2 + NO_3)$-N
		ug/g soil			
	O	48.	45.	50.	49.
1	high	37.	41.	36.	55.
	low	52.	52.	50.	63.
	O	37.	49.	41.	58.
2	high	35.	45.	40.	50.
	low	32.	47.	51.	71.
	O	34.	56.	34.	69.
3	high	35.	56.	32.	64.
	low	33.	52.	34.	70.
	O	31.	38.	38.	77.
4	high	37.	34.	43.	71.
	low	37.	39.	36.	86.
	O	41.	34.	43.	79.
5	high	41.	37.	55.	86.
	low	39.	44.	53.	95.
	O	52.	49.	65.	89.
6	high	58.	44.	65.	97.
	low	53.	47.	76.	102.
	O	37.	35.	42.	99.
7	high	38.	34.	45.	104.
	low	34.	34.	42.	114.
	O	42.	36.	45.	105.
8	high	37.	34.	46.	108.
	low	48.	36.	42	121.

As found for the first soil, there was no significant difference in the inorganic nitrogen irrespective of whether the soils were treated with cyanazine or atrazine. However, in contrast to the finding with the first soil, there was a significant difference at 10% between the herbicide levels. The extractable inorganic nitrogen was higher in the uncropped treatments than the cropped treatments, however, there was no interaction between the herbicide levels and the cropping pattern, that is, whether cropped or uncropped.

TABLE 4: EFFECT OF APPLICATION OF CYANAZINE ON AMMONIFICATION AND NITRIFICATION IN SOIL 2

Time Wks.	Rate	Cropped		Uncropped	
		NH_4-N	$(NO_2 + NO_3)$-N	NH_4-N	$(NO_2 + NO_3)$-N
		ug/g soil			
	O	48.	45.	50.	49.
1	high	53.	59.	54.	56.
	low	55.	63.	38.	69.
	O	37.	49.	41.	68.
2	high	46.	69.	52.	85.
	low	34.	54.	42.	71.
	O	34.	56.	34.	99.
3	high	35.	51.	35.	107.
	low	34.	53.	35.	71.
	O	31.	38.	38.	98.
4	high	33.	42.	42.	107.
	low	34.	38.	40.	76.
	O	41.	34.	43.	108.
5	high	42.	23.	47	98.
	low	41.	34.	47.	77.
	O	52.	49.	65.	117.
6	high	58.	52.	59.	107.
	low	51.	45.	61.	97.
	O	37.	35.	42.	120.
7	high	34.	38.	39.	130.
	low	36.	36.	38.	111.
	O	42.	36.	45.	125.
8	high	42.	39.	46.	139.
	low	45.	43.	46.	132.

TABLE 5

MEAN TOTAL INORGANIC NITROGEN (ug/g SOIL) SHOWING STATISTICAL COMPARISON OF VALUES*

1A Cropped	92.46ab	79.09a	70.72a	64.65a	71.44a	112.05b	69.33a	81.50a
1A Uncropped	90.19ab	87.22ab	65.01a	84.61ab	95.89b	133.23c	126.78c	149.96c
2A Cropped	91.60ab	81.67a	89.31ab	71.87a	78.24a	100.61b	70.76a	77.76a
2A Uncropped	101.13a	107.08a	108.91a	119.07a	136.96b	164.54b	148.45b	156.10b
1C Cropped	87.71b	81.35b	75.95ab	67.61a	64.39a	92.34c	71.09b	79.08b
1C Uncropped	89.86a	87.87a	84.61a	78.56a	91.47b	111.50b	102.28b	112.27b
2C Cropped	107.81b	96.30b	87.86ab	72.36b	71.30a	107.92b	72.03a	82.16ab
2C Uncropped	92.73b	119.07b	126.91b	133.73b	140.00b	168.51c	159.90bc	177.02d

1 — Soil type 1

2 — Soil type 2

A — Atrazine

C — Cyanazine

*Values followed by the same letter in each row are not significantly different at 5% level by LSD test.

Discussion

Although herbicides have been in use for the control of weeds in the developed countries for sometime, it is only of recent that their use has started to assume importance in this country especially at the commodity research stations and the Universities' research farms. For most of the time, the effect of these herbicides have been looked at from the view point of being able to control weeds and recommendations so far have been solely based on this property. However, a very delicate microbiological balance such as nitrification is very important to consider when these foreign agents are being introduced into the soil.

From all available evidence, it seems that workers who have found that herbicides inhibit nitrification are those who have used higher concentrations than recommended (Hale *et al* quoted by Andus, 1976; Otten *et al;* 1957). Also, it appears that inhibitions so far reported were more pronounced with sandy soils having low organic matter and buffering capacity and with heavy applications of herbicides.

The increase in the inorganic nitrogen with time could not be due to the fact that the herbicides have been rendered less effective by degradation during the time period of this experiment because Usoroh (1976) working with Atrazine and some other herbicides and using the same concentration as we used found that at 3-kg a.i./ha, there was still more than half of the original concentration of the Atrazine remaining in the soil after 5½ weeks and at 6-kg a.il, it took about 8 weeks for this concentration to be halved.

Under field conditions, it is possible to surmise that the absence of any adverse effects of herbicides on soil biochemical processes is that crop plants do break them down and render them less active. However, these results indicate that the absence of any adverse effects as far as soil nitrogen mineralization is concerned of the two herbicides could not be due only to the fact that corn plants break them down because the soils treated with herbicide and without crops also behaved similarly.

The result of the present study indicates that these two herbicides -Atrazine and Cyanazine have no adverse effect on ammonification and nitrification if used at the recommended dosages or even at double the recommended dosages. But since the weeds could be effectively controlled at the recommended dosages, it would be better to use the recommended dosages instead of anything more since nothing would be gained in terms of weed control or in terms of other positive effects like enhancement of nitrification.

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