Short communication

Weed control efficiency of reduced atrazine doses and its effect on soil organisms in maize (*Zea mays* L.) fields of south western Nigeria

Olabode, O.S*, Adesina, G.O., and Babajide, P.A.
Department of Agronomy, Ladoke Aknitola University of Technology (LAUTECH), P.M.B. 4000, Ogbomoso, Nigeria.

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Abstract

Two field experiments were conducted to assess the weed control efficiency of four graded doses of atrazine (100, 75, 50, and 25% of the recommended dose of 2.5 kg·a.i. ha^{-1}) and hoeing (control) as well as its effects on soil biota. Although the highest weed control efficiency was achieved with full dose of atrazine, there was no significant ($p = 0.05$) difference between this and the lower rates. The lower doses, however, were superior to hoe weeding. Differences in maize yields were also not statistically significant, implying the economic advantages of using 25% recommended dose. Response of soil organisms to atrazine doses varied with organisms. Significantly ($p = 0.05$) higher earthworm population was observed in the 0, 25, and 50% doses compared to 75 and 100%. The highest number of worm cast (9.90) was obtained in the control while the least (3.47) was for the 100% recommended rate. Similarly, bacterial population was inversely related to atrazine rates with the highest values for the control (290 x 10^6 cfu·g^{-1}) and the least in the 100% recommended rate (29 x 10^6 cfu·g^{-1}). Fungi and ascomycetes, however, showed a reverse trend.

Keywords: Application rate, Earthworms, Herbicide persistence, Soil biota.

Introduction

Atrazine, 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine, is a selective systemic herbicide having both knockdown effects and residual activity. It is one of the most popular herbicides in Africa and particularly in Nigeria, despite criticisms against its continued use in crop fields (Davis, 1993). Ease of availability, low price, and efficiency are the factors contributing to its popularity (Adesina et al., 2009). Atrazine behaviour in the soil is influenced by soil type, pH, temperature, organic matter content and moisture availability (Larsen et al., 2001). Excessive rates are known to eradicate soil microorganisms or suppress their activities (MAFF, 1997), implying the need for reducing herbicide doses. Herbicidal pollution of soils and environment including water bodies being a major concern, this experiment was designed to evaluate the efficacy of atrazine at lower dosage rates and assess its impact on the soil biota in southwestern Nigeria.

Two field experiments were conducted at the Teaching and Research Farm, Ogbomoso (8°10'N, 4°10'E), during the rainy seasons of 2004 and 2005. The mean annual rainfall was 139.7 and 128.3 mm respectively for the two years. The soil of the experimental site was a sandy loam with pH 6.5, and containing 0.31% N, 2.3% organic carbon, 6.48 ppm P, and 0.41 meq100 g^{-1} K. The dominant weed was *Tithonia diversifolia* (Hemsl.) A. Gray. Other important weeds included, *Digitaria horizontalis* Willd., *Axonopus compressus* (Sw.) P. Beauv., *Imperata cylindrica* Linn., and *Amaranthus spinosus* Linn. An area measuring 30 x 21 m was ploughed and disc-harrowed, and a randomized complete block design experiment with three replications (5 x 5 m plot size) was laid out. Five treatments, *viz*., 100, 75, 50, and 25%

*Author for correspondence: Phone +234 805 450 4170; Email <lakinsina@yahoo.com>.

of the recommended 2.5 kg·a.i.ha^{-1} of atrazine along with a no herbicide control (hoeing) were evaluated. Maize (cv. T2SRY) was sown at a spacing of 75 x 50 cm with three seeds per hill. This was thinned to two seedlings to achieve a plant density of 53333 ha^{-1}, two weeks after planting (WAP). Atrazine was applied pre-emergent on rain-wetted soil using a knapsack sprayer (model Cp3) at the rate of 200 L·ha^{-1} spray volume. The control plots were weeded at three and six WAP by hoeing. Maize was fertilized both at planting and tasseling stages using NPK fertilizer 15-15-15 and urea (46% N) at the rate of 133 kg·ha^{-1}. Biometrical observations and grain yield were recorded.

Effectiveness of the atrazine rates to suppress weed growth was assessed by counting weed occurrence at two, four, and six WAP (quadrat method). Weed dry matter was also determined at six WAP after drying the samples at 80^{o}C for 48 h in a hot air oven. Maize grain yield was determined per plot by harvesting the cobs, shelling, and weighing the grains after drying to 12% moisture content. Earthworm cast was determined using the quadrat method and the soil samples for microbial population estimation were collected at eight weeks after soil treatment, using a set of core samplers (15 x 10 cm). Population count was done for bacteria, fungi, and actinomycetes by pour plate technique, replicated three times. Mean data for the two years were subjected to analysis of variance and means separated by Duncan's multiple range test (DMRT) (Steel and Torrie, 1980).

There was no significant difference between the control and other treatments in terms of plant height except for the 100% recommended dosage rate (Table 1). Maize stem diameter was highest (3.0 cm) for the 100% rate and lowest (1.0 cm) for the 25% herbicide rate. A similar trend was discernible for leaf area index of maize also. There were no statistically significant variations in yield and yield parameters among the treatments and the control (Table 1). In contrast, atrazine dosage significantly affected weed control efficiency (Table 2).

Table 1. Effects of rates of application of atrazine on growth and yield of maize in south western Nigeria.

Rates of application (% of recommended rate (2.5 kg·a.i.ha^{-1})	Plant height (m)	Stem diameter (cm)	Leaf area index (cm^2)	Cob length (cm)	Weight of 100 seeds (g)	Grain yield (kg·ha^{-1})
0 (control; hoeing)	1.29^{b}	2.00^{ab}	385^{a}	24.4	16.9	5810
25	1.36^{b}	0.01^{b}	381^{a}	23.0	17.7	5549
50	1.07^{b}	0.02^{ab}	394^{ab}	26.3	18.0	5875
75	1.40^{b}	0.02^{ab}	391^{a}	23.7	18.4	5551
100	1.64^{a}	0.03^{a}	383^{a}	24.5	19.0	6004

Means followed by the same letter along the column are not significantly difference (p = 0.05) by DMRT.

Table 2. Effects of atrazine on weed control efficiency and soil biota of treated maize soils in south western Nigeria.

Rates of application (% of recommended rate) (2.5 kg·a.i. ha^{-1})	Weed density (No·m^{-2}) at 2 (weeks after sowing)	4	6	Weed dry matter (g·m^{-2})	Bacterial count (cfu·g^{-1} 10^6)	Fungal count (cfu·g^{-1} 10^6)	Actinomy cetes (cfu·g^{-1} 10^6)	Worm cast (No·m^{-2})
0 (control; hoeing)	14.3^{a}	14.1^{a}	8.4^{a}	102^{a}	290	4	2	9.9^{a}
25	4.8^{b}	5.2^{b}	4.4^{b}	80.6^{ab}	280	13	12	6.0^{ab}
50	4.7^{b}	4.0^{b}	2.9^{b}	41.0^{b}	206	26	4	4.6^{b}
75	4.7^{b}	4.0^{b}	2.5^{b}	41.8^{b}	50	30	6	3.6^{b}
100	1.6^{c}	1.7^{c}	1.9^{c}	18.1^{c}	29	25	3	3.5^{b}

Means followed by the same letter along the column are not significantly difference (p = 0.05) by DMRT; cfu·g^{-1} = colony forming units per gram sample.

The best weed control was achieved through the application of 100% of recommended rate. Although there was no significant difference between the weed control efficiencies of atrazine rates less than 100%, all herbicidal treatments were superior to hoeing.

The satisfactory weed control efficiency of atrazine at rates as low as 25% of the recommended dose denotes that blanket recommendation of the chemical at 2.5 kg·a.i.ha^{-1} is probably unnecessary. Lower rates will have the intrinsic advantages of reduced weed control costs and increased profitability. In Nigeria, the current cost of atrazine ranges between ₦[†] 800 and ₦ 900 ($5 and $6) per litre (i.e., between ₦ 4, 000 and ₦ 4, 500 or $25 and $30 for the full dose of 5 L·ha^{-1}). Our results denote that as much as 75% of this cost could be saved by reducing the rates of atrazine application.

Different organisms responded differently to atrazine rates (Table 2). For example, earthworm population decreased with increasing rates of application while actinomycetes and fungal populations increased. Bacterial population in the soil was also inversely related to the rate of application of atrazine, implying detrimental effects on the environment**.** In particular, the decrease in the number of worm cast with increasing rate of application in the present study indicated that earthworms are highly sensitive to high doses of atrazine. Fischer (1989) also reported similar results. Overall, direct monetary gains associated with reduced quantity of herbicide application and higher activity of certain soil biota, which enhances soil fertility, are distinct advantages of using reduced doses of atrazine in the maize fields of southwestern Nigeria.

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[†] Naira (₦) is Nigerian currency. One American dollar ($) is exchanged between ₦150 to ₦153; January 2010.