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# THE ADSORPTION OF IMAZAPYR BY THREE SOIL TYPES IN INDONESIA

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**ABSTRACT**

The adsorption of imazapyr in three Indonesian soil types was investigated with labelled $^{14}C$-imazapyr using Freundlich adsorption isotherm. The availability of adsorbed imazapyr to plants as affected by washing and liming was assayed using root elongation of rice seedlings.

Red-Yellow Podsolic soil adsorbed imazapyr more than Andosol and sandy soil of Laladon. The adsorption was greater at lower pH. Washing seemed to reduce the concentration of imazapyr as shown by the increasing length of rice roots. On the other hand liming facilitated higher concentrations of imazapyr in the solution as shown by the reduction of rice root length.

The practical implication is discussed.

## INTRODUCTION

Upland rice established in pot experiment by zero tillage technique on alang-alang sprayed with imazapyr at 1.5 kg a.i./ha died immediately after germination (Tjitrosemito and Purwanto 1991). However, imazapyr applied at 2.0 kg a.i./ha to soybean, planted using zero tillage technique in the field during the wet season, did not show any phytotoxic effect (Tjitrosemito and Suwinarno 1988). To understand its fate in soil, imazapyr adsorption in various soils and the effect of liming and washing were investigated.

## MATERIALS AND METHODS

The experiment was carried out at the Laboratory of Pesticide Science, Faculty of Agriculture, Kobe University, Japan. Three soil types, i.e. Red-Yellow Podsolic soil (RYP), Andosol and sandy soil of Laladon were air dried, and sieved through a 1 mm sieve. The pH was measured in a 1:1 (w/v) soil: deionized water/slurry using pH meter (model COM-10, DKK Denki Kagaku Keiki Co. Ltd.). The pH values were 3.75; 4.83 and 5.40 for RYP, Andosol and sandy soil of Laladon, respectively.

**Adsorption**

Commercially formulated imazapyr (Assault) was combined with $^{14}$C-ring labelled imazapyr (specific activity: 43.916$\mu$Ci/mg) to obtain initial concentration of 5, 25, 45 and 65 $\mu$M. Five grams of air dried soils (sieved through 1 mm) and 10 ml of herbicide solution were placed in 30 ml vial. The samples were equilibrated by shaking on a wrist action shaker for 24 hours at room temperature. The mixtures were transferred to centrifuge tubes and spun at 15 000 x rpm for 30 minutes. A 2-ml aliquot was removed from each tube and placed in 20 ml of scintillation cocktail and the $^{14}$C-activity was determined by scintillation spectrophotometry. Adsorption isotherms were constructed using best-fit regression equations. Freundlich constant $K_f$ and 1/n were calculated from the equation:

$$\log (x/m) = \log K_f + (1/n) \log C$$

where, x/m = the amount of herbicide adsorbed ($\mu$mole/kg)
C = herbicide concentration ($\mu$mole/I) in solution after equilibrium
Kf = Freundlich constant, an indicator of relative adsorption of herbicide at unit concentration (i.e. C = 1 $\mu$mole/1)
(1 /n) = indication relative linearity between adsorption and concentration.

**The Phytotoxicity of Imazapyr**

A rice bioassay was conducted by placing 5 g of air dried soil into 30-ml tubes containing commercially formulated imazapyr. The mixtures were allowed to equilibrate for 24 hr by shaking in a shaker. After equilibration, washing treatment was done by replacing the solution with deionized water and later on, 10 pre-soaked rice seeds were put in each tube.

After 3 days, the rice root length was measured and analysed statistically.

The treatments consisting of soil (Red-Yellow Podsolic Soil, Andosol and Laladon sandy soil), imazapyr (0, 0.1 and 0.2 ppm), liming (addition of $CaCO_3$ at 0.1 % (-/ + )) and washing (- / +) were combined factorially and randomized completely.

## RESULTS AND DISCUSSION

The relationship between the amount of adsorbed imazapyr and its equilibrium concentration in 3 types of soil is presented in Figure 1.

Red-Yellow Podsolic soil, the highly weathered soil with low pH adsorbed more imazapyr than Andosol or Sandy soil of Laladon. The addition of $CaCO_3$ somehow reduced the adsorption considerably.

The calculation of Freundlich equation showed the characteristic of adsorption (Table 1).

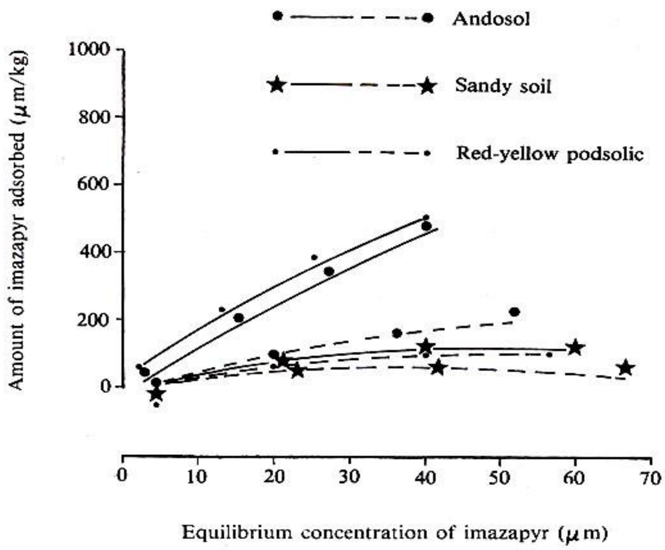


Figure 1 . The relationship between the amount of imazapyr adsorbed and its equilibrium concentration

From Table 1 the value of (1/n) ranged from 0.67 to 1.10 indicating a nonlinear relationship between the amount adsorbed and the equilibrium concentration. Freundlich constant of RYP showed the highest value (246.0μM/kg) indicating that it has the highest affinity for imazapyr. In RYP soil alang-alang is usually found abundantly.

Table 1. Relative adsorption of imazapyr (Kf) and coefficient of regression ($r^2$) on soils.

| Soil | Lime | $K_f$(µ mole/kg) | 1/n | $r^2$ |
|---|---|---|---|---|
| Red-Yellow | | | | |
| Podsolic Soil | 246.0 | | 0.84 | 0.99 |
| (pH 3.75) | + | 98.0 | 0.67 | 0.99 |
| Andosol | 120.5 | | 0.98 | 0.99 |
| (pH 4.83) | + | 34.7 | 1.05 | 0.98 |
| Sandy soil of Laladon | 17.4 | | 1.10 | 0.92 |
| (pH 5.40) | + | 15.9 | 0.95 | 0.77 |

When the values of $K_f$ and pH were examined, there was a linear relationship, i.e. $Y = 756.22 - 134.4x$ ($r^2 = 0.98$), where $Y = K_f$ and $x$ = pH value. The adsorption of imazapyr increased with the decrease in soil pH, similar results were reported by Stougaard *et al.* (1990), Wehtje *et al.* (1987) and Arnold (1981).

When the soil was limed, soil pH increased and presumably more imazapyr molecules stayed in the solution.

## Phytotoxicity of imazapyr

Rice (Norin No. 8) as a test plant in this bioassay showed a severe root length reduction when exposed to the soil treated with 0.1 or 0.2 ppm of imazapyr solution (Table 2 a).

Table 2. Root length (mm) of rice as affected by imazapyr and washing, liming, and soil types.

| Treatments | Imazapyr (ppm) | | | |
|---|---|---|---|---|
| | 0 | 0.1 | 0.2 | |
| a **Washing** | | | | |
| No washing | 32.7 | 18.3 | 14.7 | |
| | | | | LSD (5%): 5.3 |
| With washing | 35.1 | 28.2 | 20.5 | |
| b **Liming** | | | | |
| No liming | 35.1 | 27.2 | 18.7 | |
| | | | | LSD (5%): 6.1 |
| With liming | 31.2 | 19.4 | 15.6 | |
| **c Soil** | | | | |
| Red- Yellow Podsolic | 31.8 | 28.7 | 20.7 | |
| Andosol | 31.0 | 20.3 | 16.8 | |
| | | | | LSD (5%): 5.3 |
| Sandy soil of Laladon | 23.8 | 20.8 | 15.3 | |

The reduction of root length was modified by washing. Root length was increased from 18.3 mm to 28.2 mm and from 14.7 mm to 20.5 mm for 0.1 ppm and 0.2 ppm imazapyr treatment, respectively.

It seems that washing reduced the concentration of imazapyr in the solution, so less phytotoxicity was experienced by the rice root. It indicates that imazapyr can be leached away by the flowing water. On the other hand liming (0.1% $CaCO_3$) increased the phytotoxicity to the rice plant as shown in Table 2 b.

The soil also contributed differential response to the rice root elongation. The availability of imazapyr seems greater under the sandy soil of Laladon (Table 2 c).

The results of this experiment may explain the different results of imazapyr on crop growth, when imazapyr is applied during or at the end of the dry season. The crop introduced in the following wet season may suffer from imazapyr phytotoxicity. However, when imazapyr is applied in the wet season, crops established one month later will escape imazapyr injury because imazapyr molecules would have been leached by the rainfall. Liming will further speed up leaching if carried out long enough before crops are planted.

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