Soil-Adsorption of Quinclorac in the Dynamic Paddy Water-Soil System

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INTRODUCTION

Most of *Solanaceae* crops are very sensitive to quinclorac. The most sensitive tomato does not grow normal when it is grown with the irrigation water or soil containing quinclorac at 10 and 0.1 ppb, respectively. Because of this property quinclorac is not used in Korea and Japan inspite of excellence of the herbicide for the transplanted and direct-seeded rice. Developer of this herbicide introduces it 'being only slightly absorbed by the soil;relatively mobile;this mobility increasing with higher percolation rates in fields'. We found quinclorac is quite easily and much adsorbed to and desorbed from the soil. This untight binding of quinclorac to the soil confers it the mobile nature in the water-flowing paddy field. Its behavior is contrasted to that of the herbicide little adsorbed or very tightly adsorbed. The former is freely mobile while the latter is immobile. In this sense the dynamics of ad- /de-sorption of quinclorac is of interest.

ADSORPTION : Quinclorac was adsorbed onto the sandy clay-loam soil rapidly and reached at dynamic equilibrium in 6 hours. The adsorption at equilibrium was 60 μ g of quinclorac per g of air-dried soil when the initial concentration of quinclorac in the soil-solution was 10 ppm. The adsorption increased linearly with quinclorac concentration. The adsorbed quinclorac accounted for 60 to 64% of the quinclorac available for adsorption in the soil-solution over the initial concentration range of 1 ppm to 30 ppm.

The adsorption of quinclorac to the soil was better described by the Freundlich isotherm than the Langmuir isotherm. Quinclorac showed the coefficient of the distribution between soil and soil-water (K_d) from 6.22 to 17.85, and the Freundlich adsorption coefficient (K_f) of 12.483. On the Freundlich isotherm, the value of $1/n$ of quinclorac was less than 1; the adsorption of quinclorac onto the soil seems more affected by organic matter than the property of the clay mineral particles.

DESORPTION : Desorption of quinclorac from soil was directly proportional to time and the residual concentration of quinclorac. The desorption was much slower process than the adsorption and it did not reach at equilibrium within 36 hours. At 36 hours of desorption 30 to 40% of the quinclorac in the soil was desorbed into soil-solution.

The desorption of quinclorac could be described by the Freundlich isotherm. The K_d ranged 15.60~25.83 and the K_f was 12.0814 in the desorption process, very close value to K_f of 12.483 in the adsorption.

MOVEMENT IN THE PADDY FEILD : The peak concentration of quinclorac in the flood-water of the paddy was about 160 ppb which occurred 1 to 2 days later the application of 300g a.i./ha wettable powder of quinclorac. Since 20th days after application, its concentration dropped to a value less than 1 ppb. The concentration of quinclorac in the soil-water flowing downward at 30 cm to 90 cm depth reached the peak about 10 days later the application. The maximum concentration in the soil-water at 1 m deep in the soil was 10 ppb level.

EFFECT OF DOWNWARD WATER-FLOW RATE : Percolation rate of flood water on the paddy has shown a profound effect on the downward mobility of quinclorac in the soil. The concentration of quinclorac in the downstream below the plough-soil was 4.6, 2.7 and 3.1 times greater on the 5th, 10th and 20th day after application of quinclorac at its use-rate in the paddy of 4 cm-percolation a day than in the paddy of 1 cm-percolation a day. The initial greater mobility of quinclorac in the leaky paddy seems to be arisen from less binding to the soil while the later greater concentration may be arisen from a greater desorption.

HORIZONTAL UNDERGROUND MOVEMENT : An apparatus simulating underground water flow under different hydraulic pressures was devised:the iron pipes, 25 cm in inner diameter and 200 cm long path were packed with the loam and sandy clay loam soils at 10 to 12 kg/cm² and given with 30, 50 or 70 cm static hydraulic gradient. On achieving a steady state horizontal water flow, quinclorac containing water at 1 ppm was supplied steadily for a month. Under this dynamic condition the soil reached saturation in adsorption of quinclorac in about 15 to 25 days depending on the soil type and hydraulic pressure. The soil-adsorbed quinclorac by 20 days accounted for more than 99.360 % of the total amount supplied. This suggest that the adsorption is not the main cause for its after-crop troubles, but the extreme sensitivity of tomato to quinclorac and the easier desorption of it with flow of soil water are.

Fig 1. Kinetics of Soil-Adsorption.

Fig 2. Freundlich plot of Soil-Adsorption.

Fig 3. Desorption from Soil-Residue

Fig 4. Movement in the Paddy Field.

Fig 5. Effect of Downward Water-Flow.

Fig 6. Soil-Adsorption during Steady-State Horizontal Water-Flow(2m distance)

Table 1. Soil-Adsorption of Quinlorac in a Simulated System of Steady State Horizontal Flow of Groundwater containing quinlorac at 1000ppb under different hydraulic force. The amount of soil-adsorbed quinlorac is expressed as % of the amount of the quinlorac supplied.

Soil type		Sandy loam			Loam		
Hydraulic head (cm)		30	50	70	30	50	70
Duration of Steady-State Flow (days)	5	99.936	99.974	99.926	99.936	99.824	99.876
	10	99.842	99.962	99.846	99.873	99.469	99.848
	20	99.746	99.763	99.576	99.725	99.361	99.748