EFFECTS OF RESIDUE MANAGEMENT ON SUGARCANE YIELD

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We investigated the effect of sugarcane residue (mulch cover) resulting from the combine harvester on sugarcane yield and also quantified the decay of residue post harvest. The study consists of three treatments concerning the mulch left on the field after harvest. The treatments include (1) burning the mulch after harvest, off-barring and cultivating in the spring; (2) sweeping the mulch off the top of the row after harvest, off-barring and cultivating in the spring; and (3) leaving the mulch on the field after harvest, off-barring and cultivating in the spring. Treatment 3, where the mulch is not removed, may be best regarded as a no-till treatment that is a commonly used soil conservation measure. Sugarcane population, yields, and quality of runoff water are being measured for each treatment.

Sugarcane Yield

During the 2003 growing season, we implemented three cultural practices: namely burning of the mulch residue, sweeping, and no-till where the residue was not removed. To compare the yields of sugarcane biomass and sugar from sugarcane fields with three residue management practices grown on a Commerce silt loam soil at the St. Gabriel Research Station, variety HoCP91-555 was planted on 1 September 2001. The site consisted of six 0.22-ha plots (two replications $\times$ three treatments). Each plot consisted of nine rows 450 feet in length with levees on each treatment. Plantcane was harvested, using combine harvester, on 6 December 2002. Following harvest, the residue on two plots was burned on 13 December 2002. In another two plots, the residue was removed from the top of the rows using a three-row sweeper on 15 January 2003. Using brushes with nylon bristles, a thin layer of surface soil was also removed along with the mulch and deposited in the adjacent furrows. In the remaining two plots, the residue was not removed. Based on six replications, the average yield for plantcane was 32.42 tons/acre. The first stubble was harvested on 28 October 2003. This harvest was followed by sweeping two plots on 10 December 2003 and burning of another two plots on 11 December 2003 according to our treatments. The yields from the first stubble were 31.8, 30.2, and 28.9 tons/acre, for burn, no-till, and sweep, respectively. Although no statistical differences were obtained, our 2003 results from plantcane indicated highest yield was that for the burn treatment where 5 and 9% reduction in yield was obtained for the sweep and no-till treatments, respectively (see Table 1).

Mulch Decay

To assess the effect of the presence of a surface mulch residue on the retention of herbicides, the rate of decay of the sugarcane residue was quantified. The sugarcane residue was collected randomly within each plot, by measuring multiple 1 m^2 areas and collecting all surface mulch within each area. Sampling of residue was carried out several times following harvest of the plantcane as well as the first stubble. Sampling of residue was terminated several months following harvest and when it was decided that, because of low residue amounts and surface non-uniformity, accurate residue measure was not feasible. The collected residue was dried at 55°C for 24-h and weighed. A portion of dry residue was cut into 1cm sections for herbicide retention studies in the laboratory. Another portion of the residue was ground to a powder and mixed for homogeneity as required for fiber analysis.

Results of the amount of mulch remaining on the soil surface versus age of mulch following harvest are given in Figure 1. For the plantcane, the residue decreased from 2.80+0.777 tons/acre at harvest to 2.30+0.534, 66 days after harvest. For the first stubble, the amount of residue was consistently lower than that for the plantcane. Specifically, in 2003, the amount of mulch decreased from 1.58+0.642 to 0.870+0.247 tons/acre over a five month period. Such differences may be attributed to differences in the variety, yields, soil type, as well as combine setting during harvest.

A rate of residue decay was derived based on simple linear regression where the (negative) slope represents the mass of mulch degradation per acre over time. Rate of decay for this sugarcane variety (555) was 14.99 ± 5.73 and 10.14 ± 3.75 lbs/acre/day for plantcane and first stubble, respectively. Regression analysis suggests a linear model provided a good description of the decay of the mulch for all growing seasons. Moreover, the respective slopes of the regression lines were not significantly different. We should emphasize that earlier decay results from the LCP85-384 grown on Sharkey clay suggest similar overall rates of decay. Specifically, the rates of degradations for LCP85-384 were of 18.2±3.8, 14.9± 3.8, 11.7± 7.8 lb/acre/day for the three growing seasons (plant cane, first and second stubble), respectively. These earlier measurements on LCP85-384 were carried out during the 2000 through the 2003 growing seasons.

Table 1. Sugarcane yields (HoCP91-555) for the different treatments for the first stubble which was harvest on October 28, 2003**.

TREATMENT	Replicate Number	Number of Stalk per acre	Cane Yield tons/acre	Sugar Yield lbs/ acre
Burn	1	47,200	32.1	6622
	2	46,200	31.5	6552
	Average	46,700	31.8	6587
No - Till	1	44,000	29.5	5334
	2	48.800	30.8	6197
	Average	46,300	30.2	5765
Sweep	1	42,100	27.5	5767
	2	42,800	30.3	5993
	Average	42,500	28.9	5880
LSD 0.05		NS	NS	NS

** The cane was planted September 1, 2001, and plantcane was harvested December 6, 2002. Average yield for plant cane was 32.42 tons/acre.

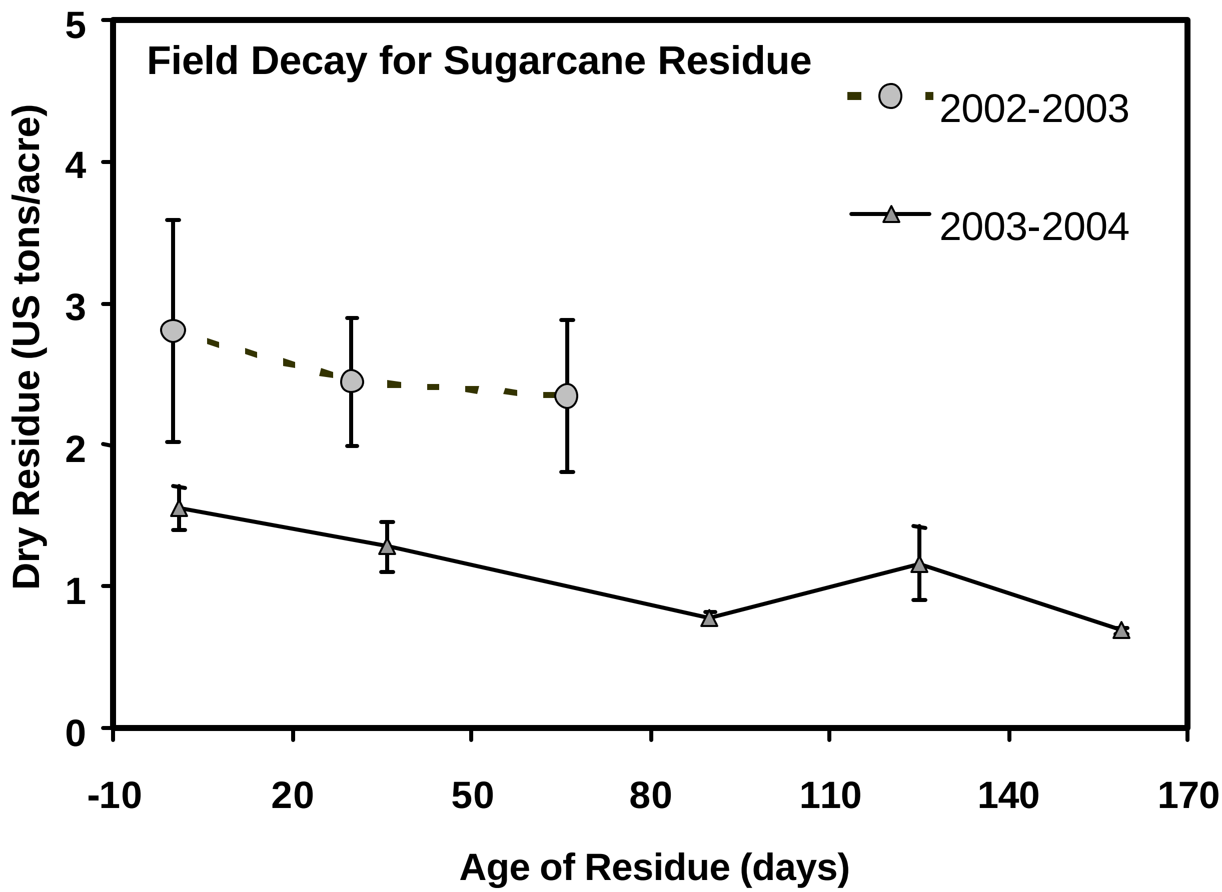

Figure 1. Field decay of sugarcane residue following harvest of HoCP91-555 for plantcane and first stubble.

ATRAZINE AND METRIBUZIN RETENTION BY SUGARCANE RESIDUE: EFFECT OF AGE OF RESIDUE

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The objective of this study was to quantify the retention of atrazine and metribuzin by the sugarcane mulch and to characterize their kinetic behavior in soil. To achieve this objective, laboratory studies of the retention kinetics of metribuzin and atrazine by the mulch residue as well as the soil were carried out. Changes in herbicide retention characteristics as a function of the age of the mulch; i.e., as the residue decays in the field, were also investigated.

To achieve our objectives, we quantified the retention of the mulch residue following cane harvest using the combine harvester over a three successive growing seasons: for plantcane, and first and second stubbles, respectively. This was carried out during 2000 through 2003 at the St. Gabriel Research Station. The sugarcane variety was LCP85-384 and the soil was Sharkey clay soil (very-fine, montmorillonitic nonacid, thermic, vertic Haplaquept), which is widely grown to sugarcane in south Louisiana.

Laboratory Measurements

To assess herbicide retention of the sugarcane mulch residue remaining on the soil surface over time, following harvest, adsorption by the mulch residue was carried out using the batch equilibration technique. The mulch samples used were collected at different times following sugarcane harvests of the 2000-2001, 2001-2002, and 2002-2003 growing seasons, representing plantcane, first stubble and second stubble, respectively. The collected residue was dried at 55°C for 24-h and weighed. A portion of dry residue was cut into 1 cm sections for our herbicide retention studies in the laboratory.

Adsorption was initiated by mixing 1g of dried and cut sugarcane mulch residue with 30 mL of the various herbicide concentration solutions in a 40-mL Teflon centrifuge tube. A wide range of atrazine and metribuzin concentrations was used. All samples were spiked with radio-labeled C-14 atrazine or metribuzin and were prepared in 0.005 M $CaCl_2$ were used. The mixtures were continuously shaken and centrifuged at $500 \times g$ for 10 minutes after each specific reaction time before sampling. A 0.5-mL aliquot was sampled from the supernatant at several reaction times up to 504 hours (21 d). The mixtures were subsequently returned to the shaker after each 0.5-mL aliquot sampling and vortexing. The collected samples were analyzed using liquid scintillation counting (LSC). The amount of pesticide retained by the residue at each reaction time was calculated from the difference in concentrations of the supernatant and that of the initial (input) solution.

Residue Retention of Herbicides

Adsorption isotherms represent the amount sorbed versus concentration of herbicide in the solution phase. Families of adsorption isotherms for atrazine and metribuzin by the mulch residue, from the second stubble are shown in Figures 1 and 2, respectively. Such relationships clearly illustrate herbicide affinities by the mulch residue as well as the extent of retention with time of reactions. Adsorption isotherms are often described by either a linear type f model ($S = K_d C$) or nonlinear (Freundlich) type of equilibrium model ($S = K_f C^N$), where S is the amount of herbicide sorbed (mg kg^{-1} soil), C is concentration in the soil solution (mg L^{-1}). The linear parameter K_d (mL g^{-1}) is the distribution coefficient which is widely reported in the literature, K_f is a Freundlich partitioning coefficient (mL g^{-1}), and N is a dimensionless parameter commonly less than unity.

The K_d values for atrazine adsorption by the sugarcane mulch residue increased with reaction times from 18.77 to 25.46 cm^3/g after 1 and 21 days, respectively (see Table 1). The metribuzin K_d values increased with reaction times from 10.58 to 14.2 cm^3/g after 1 and 21 days, respectively. These increases are representative of the strong kinetic behavior of atrazine and, to a lesser extent, metribuzin adsorption by the sugarcane mulch residue. The adsorption of both atrazine and metribuzin by sugarcane residue was initially rapid, and exhibited slower retention after 24-h of reaction time (see Figure 1 and 2). Therefore it is not recommended to rely on 24-K_d values as an estimate for potential sorption of atrazine and metribuzin by the mulch residue.

The retention capability of the mulch residue versus time of decay in the field following harvest is further depicted in Figure 3. Here we quantified the atrazine and metribuzin retention to find out the changes of adsorption characteristics caused by weather-induced changes in the field following harvest. Specifically, the K_d values were measured using 24-h batch adsorption and for individual mulch samples for the three successive growing seasons (2000-2001, 2001-2002 and 2002-2003). These results are given in Tables 2, 3 and 4 for the mulch residue collected from the residue from the plantcane, first stubble and second stubble, respectively. Strikingly, overall herbicide retention was similar over the two growing seasons and did not change significantly with age of residue or the time of decay in the field over the three growing seasons (see Tables 2 to 4). Such a finding is of significance and implies that only one K_d value is needed to quantify herbicide retention behavior and that such value is nearly time invariant for the mulch regardless of its age. Such a conclusion is valid for both herbicides.

Table 1. Linear and Freundlich model parameters for atrazine and metribuzin adsorption versus retention time by the sugarcane (LCP85-384) mulch residue. The residue was sampled on Jan 24, 2003.

Atrazine

Retention	Freundlich Model			Linear Model	
Time (d)	Kf (mL g^{-1})	N	r^2	Kd (mL g^{-1})	r^2
1	20.67 ± 2.26	0.92 ± 0.04	0.996	18.77 ± 0.58	0.935
2	23.76 ± 4.20	0.89 ± 0.06	0.988	18.04 ± 0.49	0.957
7	27.01 ± 7.60	0.95 ± 0.11	0.989	24.02 ± 0.96	0.916
14	25.12 ± 4.54	0.98 ± 0.07	0.989	24.24 ± 0.60	0.967
21	26.32 ± 4.78	0.98 ± 0.07	0.989	25.46 ± 0.64	0.966

Metribuzin

Retention	Freundlich Model			Linear Model	
Time (d)	Kf (mL g^{-1})	N	r^2	Kd (mL g^{-1})	r^2
1	13.82 ± 0.65	0.91 ± 0.01	0.994	10.58 ± 0.26	0.971
2	18.02 ± 2.49	0.88 ± 0.03	0.993	11.37 ± 0.22	0.985
7	19.28 ± 1.40	0.92 ± 0.01	0.994	13.87 ± 0.15	0.995
14	19.31 ± 1.30	0.92 ± 0.01	0.994	14.03 ± 0.15	0.995
21	19.55 ± 1.29	0.92 ± 0.02	0.994	14.20 ± 0.15	0.995

Table 2. Estimated linear and Freundlich model parameters (with 95% confidence interval) for atrazine and metribuzin adsorption by the sugarcane mulch residue (var. LCP85-384). The residue was sampled at several dates following harvest of plantcane December 8, 2000.

Sampling	Age of	Linear Model	Freundlich Model	
Date	Residue (days)	K_d (mL g^{-1})	K_f (mL g^{-1})	N
Atrazine				
03-Jan-01	26	14.99 ± 0.15	18.27 ± 1.11	0.92 ± 0.02
07-Feb-01	61	16.52 ± 0.13	19.48 ± 0.87	0.93 ± 0.01
23-Mar-01	105	15.90 ± 0.22	19.36 ± 1.82	0.92 ± 0.03
27-Apr-01	140	18.09 ± 0.13	20.70 ± 0.97	0.94 ± 0.01
Metribuzin				
03-Jan-01	26	10.00 ± 0.15	13.05 ± 0.80	0.96 ± 0.01
07-Feb-01	61	11.29 ± 0.49	10.11 ± 4.93	1.02 ± 0.12
23-Mar-01	105	11.20 ± 0.20	13.72 ± 2.46	0.94 ± 0.04
27-Apr-01	140	10.36 ± 0.10	13.31 ± 1.18	0.93 ± 0.02

Table 3. Estimated linear and Freundlich model parameters (with 95% confidence interval) for atrazine and metribuzin adsorption by the sugarcane mulch residue (var. LCP85-384). The residue was sampled at several dates following harvest of first stubble October 22, 2001.

Sampling	Age of	Linear Model	Freundlich Model	
Date	Residue (days)	K_d (mL g^{-1})	K_f (mL g^{-1})	N
		Atrazine		
30-Oct-01	12	16.21 ± 0.36	22.62 ± 3.10	0.87 ± 0.05
26-Nov-01	39	14.92± 0.39	18.28 ± 3.51	0.92 ± 0.07
20-Dec-01	63	16.72 ± 0.27	20.67 ± 2.26	0.92 ± 0.04
22-Feb-02	127	15.65 ± 0.16	18.46 ± 1.32	0.93 ± 0.02
20-Mar-02	153	17.18 ± 0.31	22.69 ± 2.63	0.89 ± 0.04
23-May-02	217	15.93 ± 0.18	18.24 ± 1.54	0.94 ± 0.03
		Metribuzin		
30-Oct-01	12	9.23 ± 0.32	10.90 ± 4.02	0.95 ±0.09
26-Nov-01	39	9.47 ± 0.20	8.49 ± 2.12	1.02 ± 0.06
20-Dec-01	63	10.47 ± 0.22	8.76 ± 2.09	1.04 ± 0.05
22-Feb-02	127	11.11 ± 0.04	10.57 ± 0.42	1.01 ± 0.00
20-Mar-02	153	10.07 ± 0.06	11.56 ± 0.67	0.96 ± 0.01
23-May-02	217	10.97 ± 0.06	12.10 ± 0.73	0.97 ± 0.01

Table 4. Estimated linear and Freundlich model parameters (with 95% confidence interval) for atrazine and metribuzin adsorption by the sugarcane mulch residue (var. LCP85-384). The residue was sampled at several dates following harvest of second stubble November 24, 2002.

Sampling	Age of	Linear Model	Freundlich Model	
Date	Residue (days)	K_d (mL g^{-1})	K_f (mL g^{-1})	N
		Atrazine		
24-Nov-02	1	20.82 ± 1.38	22.62 ± 3.10	0.87 ± 0.05
20-Dec-02	25	15.81 ± 1.49	18.28 ± 3.51	0.92 ± 0.07
24-Jan-03	63	18.77 ± 0.58	20.67 ± 2.26	0.92 ± 0.04
		Metribuzin		
25-Nov-02	1	8.52 ± 0.29	9.26 ± 2.39	0.98 ±0.09
20-Dec-02	25	10.63 ± 0.19	11.04 ± 2.21	0.99 ± 0.06
24-Jan-03	63	10.58 ± 0.26	13.82 ± 0.65	0.91 ± 0.05

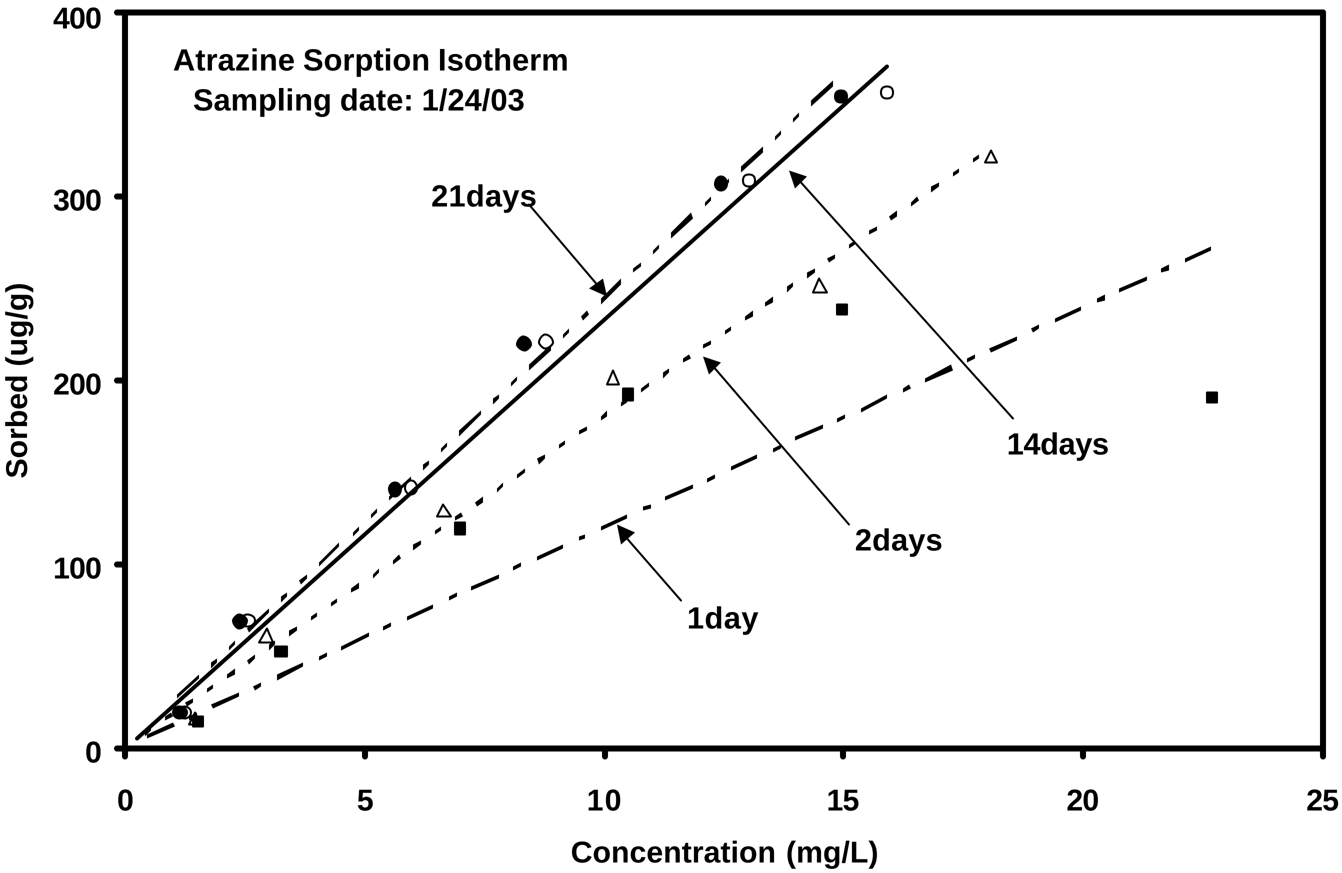

Figure 1. Adsorption isotherms for atrazine for sugarcane mulch residue at different reaction times. The residue was sampled on November 24, 2002.

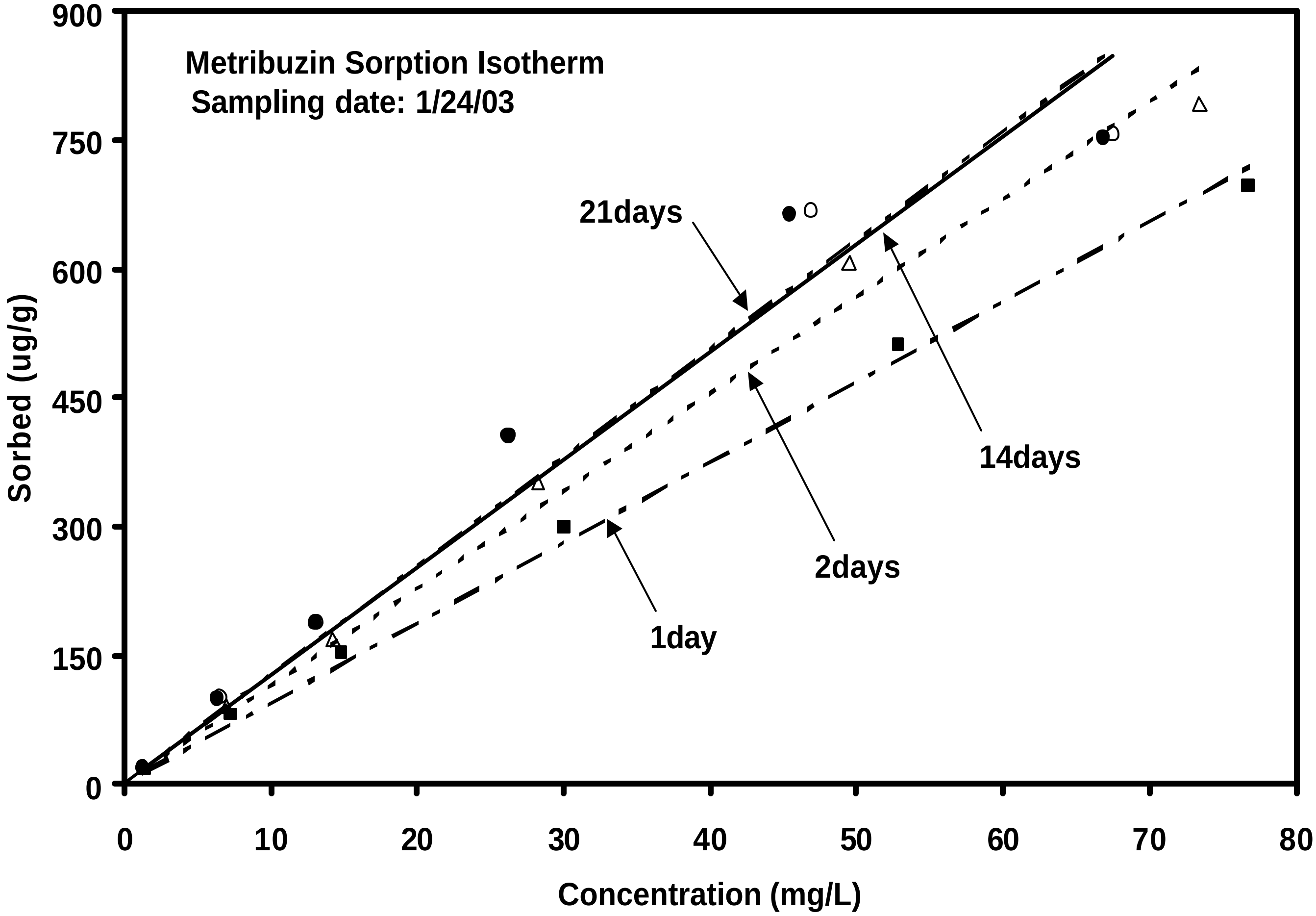

Figure 2. Adsorption isotherms for metribuzin for sugarcane mulch residue at different reaction times. The residue was sampled on November 24, 2002.

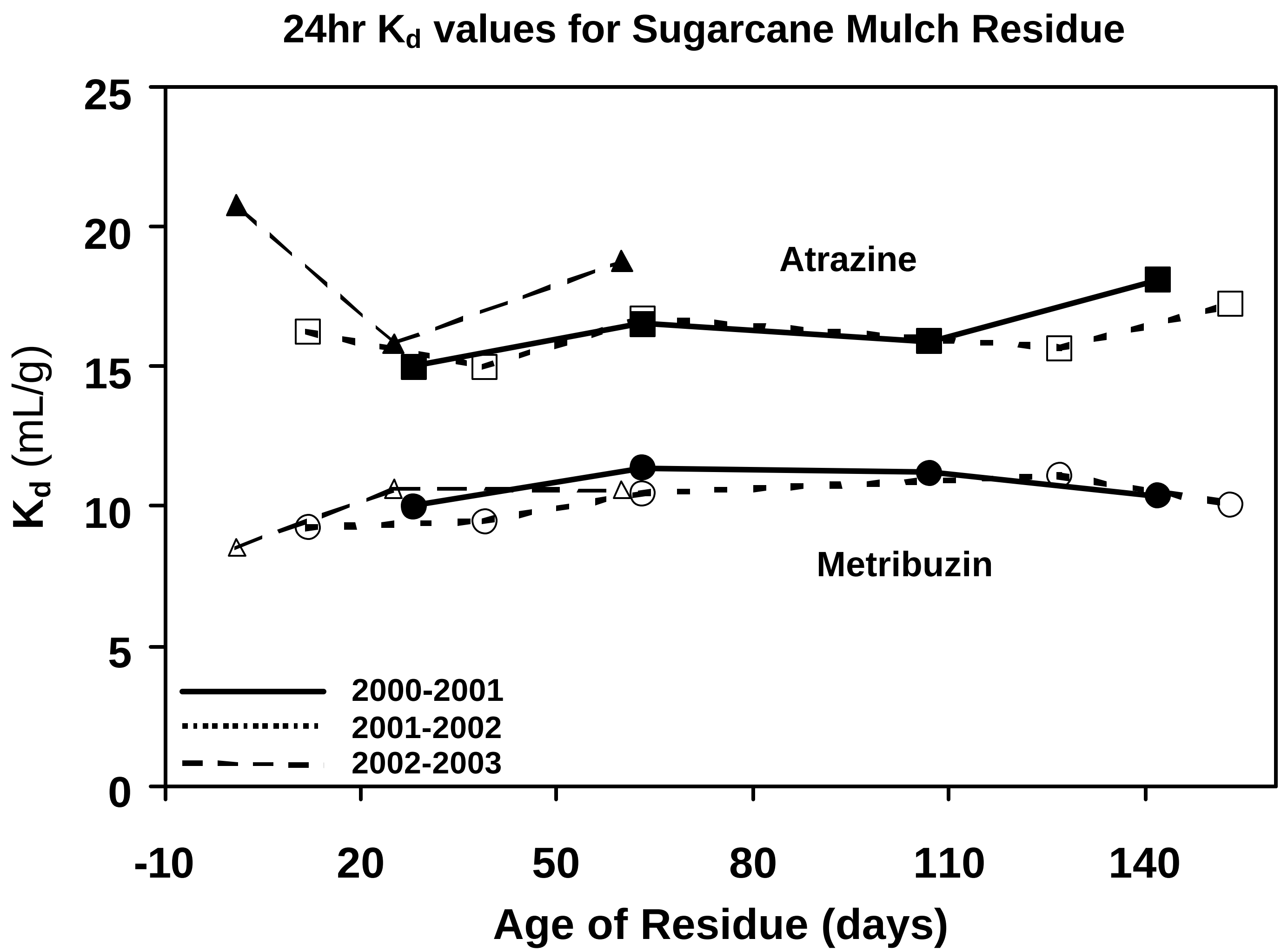

Figure 3. Distribution coefficient (K_d) for atrazine and metribuzin by the sugarcane residue versus age of the mulch during for three growing seasons.