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Water Quality as Affected by Pesticides in Rice Production

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**Arkansas Water Resources Research Center
University of Arkansas
Fayetteville, Arkansas 72701**



Arkansas Water Resources Research Center

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ABSTRACT

WATER QUALITY AS AFFECTED BY PESTICIDES IN RICE PRODUCTION

Studies were conducted to determine the environmental persistence of the rice pesticides triclopyr, 2,4-D, benomyl and quinclorac. Triclopyr half-lives ranged from <7 d to >100 d depending on depth within the soil profile and clay content. Triclopyr persistence increased as depth within the profile increased and clay content increased. The benomyl metabolite MBC was present at greater than 50% of the initial amount after 9 months in the field. In simulated carryover field studies quinclorac exhibited the greatest potential for injury to subsequent rotational crops. Cotton and soybean growth was reduced when planted at four weeks after quinclorac application. The adsorption of triclopyr to three soils was measured by the batch equilibrium technique. Freundlich isotherms were linear and resulted in K_f values of 1.60, 1.41, and 2.75 for Crowley silt loam soil from depths of 0, 0.2, and 0.6 m, respectively, within soil profile. Soil thin-layer chromatography of triclopyr resulted in R_f values of 0.42, 0.69, and 0.40 for the Crowley silt loam soil from 0, 0.2, and 0.6 m depths. In controlled temperature and water potential degradation studies, triclopyr and 2,4-D degraded more rapidly at 30 C than at 15 C. The degradation rates of the two herbicides responded oppositely to water potential. 2,4-D degraded more rapidly under anaerobic conditions, whereas triclopyr degraded more rapidly under aerobic conditions.

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INTRODUCTION

Arkansas rice growers have relied on man-made pesticides and fertilizers to achieve optimum yields. As a result, the persistence of these chemicals is becoming a very important issue because of the uncertainty of the environmental affects of small amounts remaining in soil and water. Recently pesticide use associated with rice production has aroused the suspicions of regulators and concerned citizens, especially in California (12). There is no major pool of information from Arkansas which indicates that rice production is harmful to the environment. It is important, however, that the rice industry and other interested parties implement appropriate research to determine if environmental problems are being created by current pesticide use patterns or their likelihood of occurring in the near future.

Pesticide fate research has been conducted involving dryland agriculture (5, 7, 13, 19, 21, 22, 23, 26, 27); however, these studies have not included evaluations of pesticide movement in the flooded conditions of rice culture. For the majority of commercial pesticides, total losses from runoff are 0.5% or less of the amounts

applied, unless severe rainfall conditions occur within one to two weeks after application. Exceptions are the organo-chlorine insecticides which lose about 1% regardless of weather pattern because of their long persistence. Soil surface-applied, wettable powder formulations of herbicides may lose up to 5% depending on weather and slope, because of ease of washoff of the powder (26).

A. Purpose and Objectives

The overall goal of this research is to monitor the environmental fate of rice pesticides in soil and water and to determine their potential to reach groundwater. Specific goals were to: a). determine the amount of in-situ leaching and degradation of triclopyr and benomyl at three depths in a rice soil profile, b). to determine the carryover potential of propanil, molinate, thiobencarb, triclopyr, 2,4-D, and quinclorac to subsequent rotational crops, and c). to determine the mobility, adsorption, and persistence of 2,4-D and triclopyr under controlled conditions of temperature and water potential.

B. Related Research and Activities

About 90% of California rice is grown in the

Sacramento Valley. Within this valley about 50% of the total rice acreage drains along a 105 km stretch between the city of Colusa and the confluence of the Feather and Sacramento rivers. Studies have documented that thiobencarb (S-4-chlorobenzyl-diethyl-thiocarbamate) and molinate (S-ethyl N,N-hexamethylenethiocarbamate) exist seasonally in water, sediment and biota of these drainage canals and in the Sacramento River (9). During the rice growing season a bitter taste in Sacramento city drinking water and extensive fish kills in agricultural drains have been attributed to thiobencarb and molinate, respectively (12).

In response to discovery of environmental problems associated with thiobencarb and molinate, growers were required to hold treated field water on site to promote dissipation prior to release into agricultural drains. However, during a six-day holding period thiobencarb concentrations in water did not decline significantly (9). Molinate concentrations in water declined significantly indicating that the six-day holding period facilitated dissipation of molinate. Thiobencarb was roughly equally distributed between water and soil whereas 81% of the molinate applied was dissolved in

water.

The herbicide propanil (3',4'-dichloropropion-anilide) selectively controls several annual weeds in rice (24). At normal application rates, propanil does not persist in most soils (10, 15). Several researchers have shown that biological degradation is the principle mode of dissipation of propanil from soils not subjected to flooding (2, 3, 4, 10). Two metabolites, DCA (3,4-dichloroaniline) and TCAB (3,3',4,4'-tetrachloroazobenzene), formed from the biological degradation of propanil, have been reported to be toxic to mammals (3, 28) and microbes (8).

Carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl-N-methyl carbamate) is a broad-spectrum insecticide belonging to the N-methyl carbamate family. Carbofuran applied at the recommended rate was generally dissipated within 96 h following its infusion in the plot water. Studies have indicated that carbofuran applied to rice fields remained in paddy soil, not in paddy water (11, 18). A total of 2 to 11% of the carbofuran applied was discharged in runoff water during a three month period after fields were first flooded. Maximum concentrations in runoff water from rice fields occurred within 26 days

after initial flooding (18). Results by Deuel, et al., (11) suggested that carbofuran was dissipated from rice paddy water via an adsorptive mechanism. Similar recoveries of carbofuran from unsterilized and sterilized samples indicated that carbofuran was dissipated nonbiologically.

Benomyl (1-(butylcarbamoyl)-2-benzimidazole-carbamate) has been one of the most widely used systemic fungicides for more than 20 years. Its mode of action is not well understood because its natural degradation compound MBC (methyl-2-benzimidazole carbamate) is also fungitoxic. Consequently, it has been difficult to determine the roles of the two chemicals after spray application. It is generally believed that although the fungicide is applied as benomyl, the actual fungicidal activity derives from MBC. The persistence of benomyl and MBC after spray application has received little attention. USDA studies have indicated that the half-life in a sandy loam soil is about 0.36 days with very little leaching (25). Other data reports a soil half-life of 6 to 12 months (1).

Triclopyr (3,5,6-trichloro-2-pyridyloxyacetic acid) has been used for control of broadleaf weeds and woody

plants in grassland, industrial areas, and coniferous forests. Currently it is under development for broadleaf weed control in rice, with the potential to replace 2,4-D. Triclopyr is a pyridine with similar biological activity as the phenoxy herbicides. A primary mechanism of dissipation pertinent to rice culture is photodecomposition. Triclopyr in the acid form was observed to photodegrade six times faster than the ester with typical midday, midsummer half-lives of 2.1 and 12.5 h, respectively, at the water surface at 40° Latitude (17). Data concerning the persistence of triclopyr in soil indicate that this pesticide can persist in forest soils for more than one year (16). However, data are lacking concerning its fate in rice culture.

Although considerable information is available on many of these rice pesticides no definitive studies have been implemented to evaluate their fate under rice growing conditions of Arkansas.

METHODS AND PROCEDURES

A. In-situ dissipation of triclopyr and benomyl

An experiment was established at Stuttgart, AR in June, 1990, to evaluate in-situ dissipation of the

previously mentioned pesticides. Each soil pit was excavated to a depth of 1.8 to 2.0 m. Immediately after pit excavation, a battery-operated post-hole auger was used to fabricate the proper size and location of the storage slots (Figure 1). Slots were cut into vertical sides of soil pits where soil containers with moist soil treated with known pesticide concentrations, were be allowed to reside for periods of 0, 1, 3, 6, 9, and 12 months. Degradation and leaching rates were compared using paired samples at depths of 0, 0.2 and 0.6 m.

The backhoe used for excavating the soil pits was used to collect soil from the three depths. A 10-mL aqueous pesticide solution was pipetted evenly onto 500- to 600-g field moist soil which had been thinly spread onto a polyethylene sheet. At completion of the mixing process, the treated soil was placed, along with its identifying code, into either a 500 mL glass jar closed with a perforated lid, or a 10 by 13 cm PVC pipe covered on each end with plastic mesh.

The soil-pesticide mixture in the jars is open to the soil environment but protected against leaching. By placing the PVC containers in a vertical position (screen end top and bottom), leaching within the soil pits will

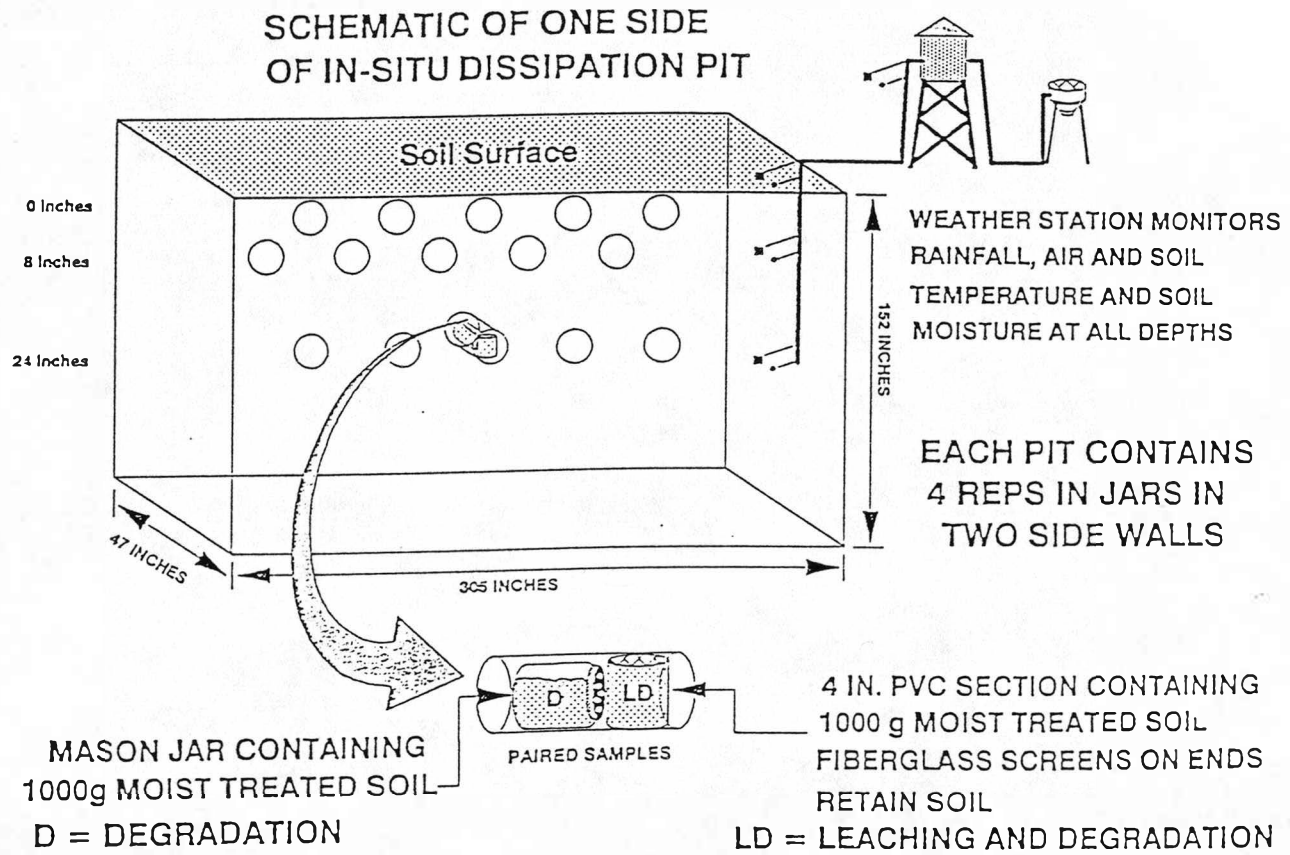


Figure 1. Schematic of in-situ dissipation pit at Stuttgart, AR.

thus be permitted. In contrast to the degradation jars, both leaching and degradation of pesticides in soil are allowed to occur in the PVC pipe. After placing all containers in their preassigned randomized locations, the excavated soil was backfilled into the pit, and mounded somewhat to allow for settling.

Each pit was marked on four corners with permanent stakes. A 10- to 15-cm permanent flood was established over the pits for the remainder of the growing season. In mid September, the flood is removed until June of the following year. This flooding scheme is designed to simulate typical flooded rice culture. To facilitate removal of the jars at the predetermined times and to prevent plant roots from penetrating the soil and perhaps entering the treated soils in the containers, all pits will be kept plant free.

On each excavation date all jars and columns were removed from the pit, dried and frozen until quantification by gas or liquid chromatography methods. Following is a plan describing the kinds and numbers of field samples that were generated:

- 2 sample types (degradation and leaching)
- 2 pesticides (triclopyr and benomyl)

- 3 depths
- 2 repetitions
- 2 replications
- 6 excavation dates (0, 1, 3, 6, 9, and 12 months)

A factorial treatment arrangement was be used with sample type (degradation vs leaching) and depth in the soil profile as factors.

Analyses of residual pesticide concentrations were as follows: for triclopyr, 10 g of soil was placed in a screw cap culture tube. Forty-five mL of basic methanol (pH 13) were added to the soil and the samples placed in a 110 C oven for 1 h. After removal from the oven, the methanol solution was filtered from the soil through a Whatman # 5 filter paper and the soil washed with three 10 mL portions of methanol. The methanol was brought up to 100 Ml final volume and an aliquot removed, acidified (pH 2) and 20 mL of water and 5 cc of NaCl added. The triclopyr extract was partitioned into benzene, cleaned up on an acidic alumina (80 to 200 mesh) column and repartitioned into benzene. The sample was concentrated to 5 mL under a stream of nitrogen, esterified with boron trifluoride in methanol and an aliquot injected into a

Tracor 550 Gas Chromatograph (electron capture detector)
under the following conditions:

Column: 1.95% SP2401/1.5% SP2250 on 100/120
Supelcoport

Flow: 95/5 Ar/CH₄ at 50 mL/min.

Detector temperature: 380 C

Injection temperature: 250 C

Oven temperature: 155 C

Injection volume: 2 uL

Retention time: 5 min.

Recovery of laboratory fortified samples was 84% ± 13% over a concentration range of 0.05 to 2.5 ppm. External quantification was employed for all determinations. Peak heights were measured by hand to the nearest 0.5 mm.

Benomyl was quantified as follows: 50 g of soil, 50 mL of acetone, and 50 mL of 1 M ammonium chloride was placed into an Erlenmeyer flask. The flask was stoppered and shaken at 200 rpm for 2 h. The extract was filtered through a Whatman # 1 filter and an aliquot removed. The aliquot was acidified (pH 2) and cleaned up with two, 25-mL ethyl acetate extractions. The pH of the aqueous phase was raised to 12 and benomyl was partitioned into

ethyl acetate. The ethyl acetate was dried with anhydrous sodium sulfate and concentrated to dryness under a stream of nitrogen. The extract was redissolved in mobile phase and quantified with an ISCO model 2350 high performance liquid chromatograph under the following conditions:

Column:	Whatman C ₁₈ Partisphere
Flow rate:	2 mL/min.
Detector:	285 nm
Injection Volume:	20 uL
Mobile Phase:	40/45/14 methanol/water/K- buffer (pH 7)
Sensitivity:	0.01
Peak duration:	1/3
Flush time:	15 s
Retention time:	1.9 min.

Recovery of laboratory fortified samples was 70% ± 9% over a concentration range of 0.05 to 1.5 ppm. External quantification was performed as described earlier.

A 5 by 6 cm core of soil was collected at each depth from each pit. These cores were sealed and returned to the lab to determine the soil-water content, pH, percent

organic matter, bulk density, particle size distribution, saturated hydraulic conductivity, and the water-retention curve of each depth (Table 1). The soils were classified on the basis of percent organic carbon, organic matter and texture. Degradation and leaching information gained from these in-situ studies should provide insight regarding the effect of soil depth on degradation rate and the likelihood that, under field conditions, pesticides varying in chemical and physical properties will leach beyond normal rooting zones.

B. Simulated carryover of six rice herbicides

The experiment was conducted at Fayetteville, AR to evaluate the potential for rice herbicides to cause injury to cotton, grain sorghum, field corn, and soybeans which might follow in a rotation or replanting. Propanil (13.4 kg/ha), thiobencarb (9 kg/ha), triclopyr (0.84), 2,4-D (3.36), molinate (11.2) and quinclorac (1.12) were applied to the soil at 2X rates and incorporated to a depth of 5 to 10 cm. The rotational crops were planted into the treated area at 0, 1, 2, 4, 8, and 12 weeks after herbicide application. At four weeks after planting plant heights were recorded. The experimental design is a split plot with herbicide as the main plot

and rotational crop and time of planting as the subplots. Four replications were used in this study.

C. Thin-layer chromatography and adsorption of triclopyr to soil

Adsorption was studied using a batch-equilibrium technique. One gram of soil and five ml of pesticide solution were placed into a glass culture tube. The pesticide solutions were prepared in 0.01 M calcium chloride containing technical grade and ring ^{14}C -labelled triclopyr (specific activity 29.5 mCi/mMole). The initial concentrations of triclopyr in solution were 0, 3.1, 6.3, 13, 25, and 50 ug/mL. The culture tube was capped and placed on a rotary shaker for 24 h. At equilibrium, the tubes were centrifuged to separate soil from supernatant. The supernatant was quantified for radioactivity by liquid scintillation counting. Isotherms were calculated using the linearized Freundlich equation $\log x/m = \log K_f + 1/n \log C$ where x/m = ug herbicide adsorbed per g soil, C is ug herbicide per mL equilibrated solution and K_f and $1/n$ are constants calculated by least squares regression.

Thin-layer chromatography was performed in the following manner: A soil-water slurry was spread across

a glass plate and allowed to dry before being used. The soil thickness varied depending on soil texture. The dried plate was divided into four (2 by 20 cm) sections and ¹⁴C-labelled triclopyr was applied to each section approximately 2 cm from the bottom of the plate. Plates were placed in chromatography developing chambers with water added as the developing solvent. After development, the plates were removed, allowed to dry and the wetting front divided into sections (1 cm each). Each section was scraped separately and placed into a vial for quantification by liquid scintillation counting. The section containing the highest percentage of radioactivity was used to calculate a mobility Rf value. The Rf value was calculated by dividing the distance travelled by the section with the highest amount of radioactivity by the total distance moved by the wetting front (Equation 1).

Equation 1.

$$\frac{\text{Distance travelled by highest } ^{14}\text{C activity}}{\text{Distance travelled by wetting front}} = Rf$$

Therefore, the higher the Rf value, the more mobile

the pesticide.

D. Degradation of 2,4-D and triclopyr

Incubation studies were performed on a Crowley silt loam soil at two soil-water contents and two temperature regimes. The water contents were saturated (anaerobic, 0 kPa water potential) and lower drainage point (aerobic, -100 kPa). Water was added to the samples periodically to maintain constant water potential. Residue analyses were conducted at 0, 1, 2, 4, 8, and 16 weeks of incubation. Analyses for triclopyr were as described earlier. Analyses for 2,4-D were as follows: 10 g of soil were placed in an Erlenmeyer flask along with 5 mL of water and 2 mL of 18 N sulfuric acid. The mixture was swirled and allowed to stand for 20 minutes. Then 50 mL of diethyl ether was added and the sample shaken at 200 rpm for 1 h. The sample was filtered through a Whatman # 1 filter and the soil washed with 25 mL of diethyl ether. The diethyl ether extracts were combined and placed in a 250 mL separatory funnel. The diethyl ether was extracted twice with 25 mL 0.5 N sodium hydroxide and discarded. The aqueous phase was acidified (pH 1) and the 2,4-D was extracted into two, 25 mL portions of dichloromethane. The dichloromethane extracts were

combined and concentrated to dryness under a stream of nitrogen. The 2,4-D was esterified with boron trifluoride in methanol, partitioned into benzene and an aliquot injected into a Tracor 550 Gas Chromatograph (electron capture detector) under the following conditions:

Column: 1.95% SP2401/1.5% SP2250 on 100/120
Supelcoport
Flow: 95/5 Ar/CH₄ at 50 mL/min.
Detector temperature: 380 C
Injection temperature: 250 C
Oven temperature: 170 C
Injection volume: 2 uL
Retention time: 2 min.

Recovery of laboratory fortified samples was 73% ± 11% over a concentration range of 0.05 to 2.5 ppm.

E. Groundwater monitoring

This study was initiated to investigate the possibility of groundwater contamination at pesticide mixing and loading sites and in surface water near rice fields. The samples will be identified and quantified with gas and liquid chromatography. Sampling will continue throughout the duration of this project.

Principle Findings and Significance

A. In-situ dissipation of triclopyr and benomyl

The general soil data is shown in Table 1. A slightly higher pH was present at the 0.2 m depth. The organic matter content was consistent at all three depths. Bulk density was greatest at 0.2 m indicating the presence of a hardpan. As a result the saturated hydraulic conductivity (Ksat) was lowest at this depth. The 0.6 m soil contained higher amounts of clay resulting in a greater water holding capacity.

Results from the in-situ dissipation field study indicated that triclopyr was not detected in the leaching containers at 0 m after 1 month (Table 2). After 3 months triclopyr was not detected at 0 or 0.2 m. At 0.6 m, 15 and 50% of the amount applied was detected in the leaching and degradation containers, respectively. A first order kinetic model was used to determine the approximate half-lives of triclopyr in the respective containers. The predicted half-lives of triclopyr at 0 and 0.2 m were less than 3 weeks. It was not possible to apply the model to the 0 m leaching data since triclopyr was not detected in these samples at 1 month. The 1/2 life at 0.6 m was 44 and 104 days in the leaching and

Table 1. General soil data¹ from the in-situ pesticide dissipation study, Crowley silt loam soil, Stuttgart, AR.

	Depth		
	0.0 m	0.2 m	0.6 m
pH	5.0	6.0	5.0
Organic matter (g/g)	0.9	1.0	1.1
Bulk density (g/cm ³)	1.41	1.59	1.44
Ksat (cm/day)	4.17	0.09	0.65
Water content at			
1500 kPa (g/g)	9.90	10.7	16.6
Sand (g/g)	8.0	9.0	6.0
Silt (g/g)	72	69	53
Clay (g/g)	20	22	41

¹Average of 7 replications.

Table 2. Residual triclopyr concentrations in the in-situ pesticide dissipation study.

Container	<u>Days of incubation</u>		Estimated half life ¹	
	28	104		
leaching	0 m	0.0	0.0	--
degradation	0 m	17	0.0	17
leaching	0.2 m	7.0	0.0	18
degradation	0.2 m	19	0.0	16
leaching	0.6 m	28	15	44
degradation	0.6 m	80	50	104

¹Assuming First order kinetics.

degradation containers, respectively.

Benomyl is not stable in water, decomposes rapidly in organic solvents and is normally quantified by measuring its degradation products, mainly methyl-2-benzimidazol carbamate (MBC) (6). Thus a high performance liquid chromatography technique for MBC was used to determine the presence of benomyl.

The measurement of a degradation product rather than parent compound makes implementation of a kinetic model somewhat difficult. Thus the results are presented as the concentration of MBC remaining at each sample removal date (Table 3). The soil from each level was fortified with the same concentration of benomyl; however, analysis of the time '0' samples revealed that there was a different rate of degradation of benomyl to MBC from time of fortification until analysis. In general, greater than 50% of the initial amount of MBC remained in soil samples at 9 months.

B. Simulated carryover of propanil, thiobencarb, triclopyr, 2,4-D, molinate, and quinclorac

Grain sorghum growth was inhibited by all herbicides except propanil when planted immediately after herbicide application (Figure 2). However, at 1 week after

Table 3. Concentration of benomyl metabolite (MBC) recovered from the in-situ pesticide dissipation study.

Container		Months of incubation					
		0	1	3	6	9	12
	(depth)	----- (ppm) -----					
leaching	0 m	1.47	1.86	1.76	0.79	0.90	0.30
degradation	0 m	1.41	1.92	2.09	1.29	1.31	0.40
leaching	0.2 m	2.42	1.41	1.78	1.98	1.73	0.80
degradation	0.2 m	2.27	1.69	1.65	2.73	2.05	1.11
leaching	0.6 m	2.93	2.26	1.79	1.98	2.14	1.46
degradation	0.6 m	3.11	3.27	2.59	1.87	1.80	1.51

application, thiobencarb is the only herbicide to cause a significant reduction in height. No height reduction was noted by any of the herbicides at 2, 4, or 8 weeks after application.

Field corn growth was reduced at 0 and 1 week after application of quinclorac (Figure 3). The other herbicides did not reduce corn growth.

Soybean growth was reduced at 0 week by quinclorac, molinate, propanil, 2,4-D, and triclopyr (Figure 4). At 1 and 2 weeks after application, triclopyr and quinclorac reduced soybean growth. Previous studies have indicated that soybeans are sensitive to triclopyr (14). Quinclorac also reduced growth at 4 weeks after application. Quinclorac is a relatively new herbicide and its phytotoxicity to rotational crops has not been documented.

Cotton growth was reduced at all planting dates by quinclorac, indicating its extreme sensitivity to quinclorac (Figure 5). Molinate and thiobencarb reduced cotton growth at 0 and 1 week after application. 2,4-D reduced cotton growth at time 0.

C. Thin-layer chromatography and adsorption of triclopyr to soil

GRAIN SORGHUM HEIGHT

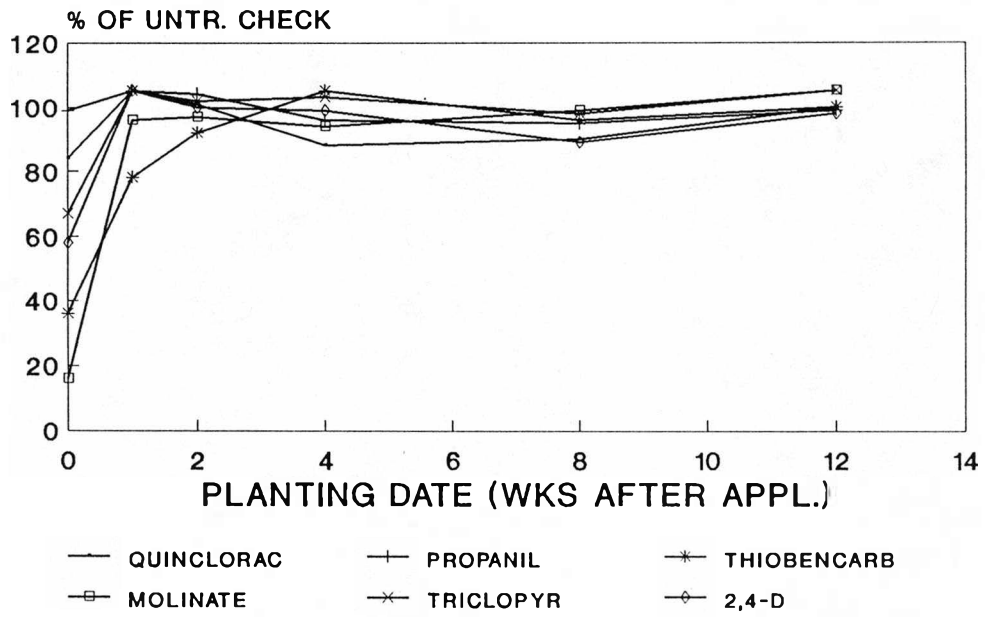


Figure 2. Grain sorghum height at each planting date. Fayetteville, AR.

FIELD CORN HEIGHT

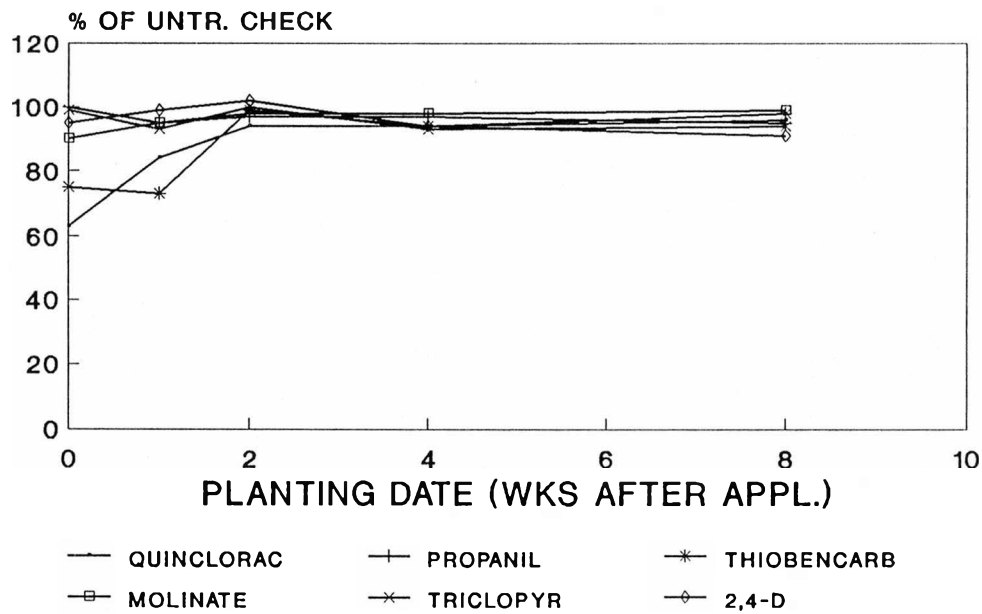


Figure 3. Field corn height at each planting date. Fayetteville, AR.

SOYBEAN HEIGHT

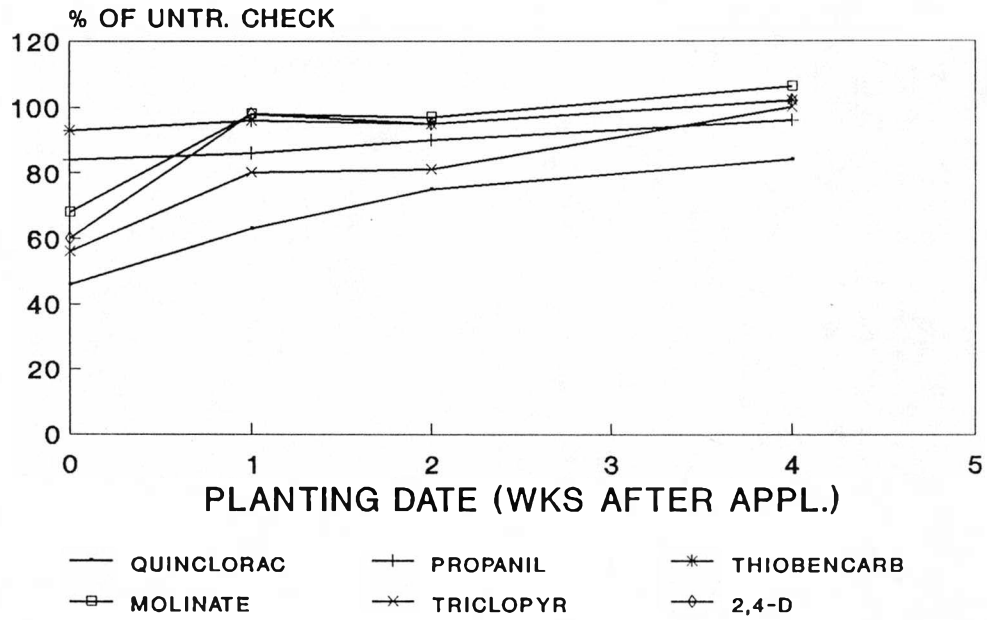


Figure 4. Soybean height at each planting date. Fayetteville, AR.

COTTON HEIGHT

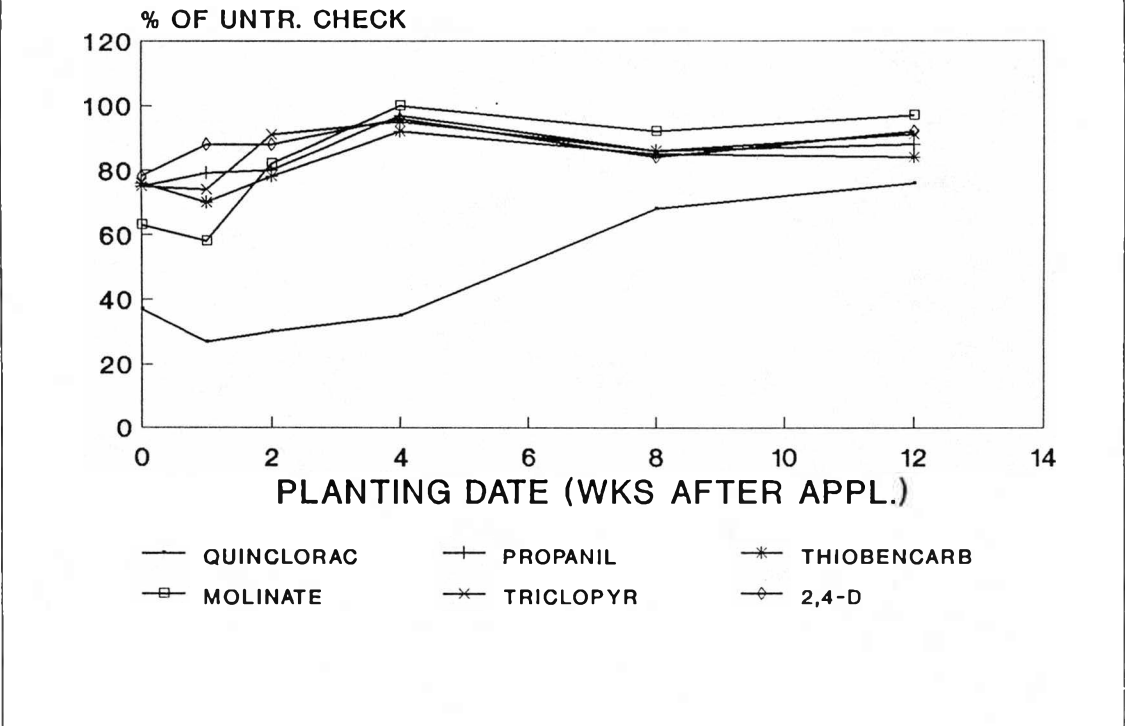


Figure 5. Cotton height at each planting date. Fayetteville, AR.

Table 4. Relative mobility and adsorption of triclopyr on soil.

Soil	Soil TLC		Adsorption	
	R _f	Standard dev.	K _f	R ²
				(ug triclopyr per g soil)
0 m	0.42	0.03	1.60	0.986
0.2 m	0.69	0.03	1.41	0.991
0.6 m	0.40	0.04	2.75 ¹	0.997

¹Significantly higher than the 0 and 0.2 m soil at the 5% level of significance.

The results of the laboratory soil TLC studies indicate that triclopyr is more mobile on soil from the 0.2 m depth (Table 4). Relatively small standard deviations indicated consistent results within soils from the three different depths. The values of the partition coefficient (K_f) show that a significantly higher amount of triclopyr was adsorbed to soil from the 0.6 m depth.

D. Degradation of triclopyr and 2,4-D under controlled conditions of temperature and water potential

Triclopyr and 2,4-D degraded more rapidly at 30 C than at 15 C (Tables 5 and 6). Triclopyr degraded more rapidly under aerobic conditions (100 kPa water potential) than anaerobic conditions (0 kPa water potential) except in the 0.6 m soil based on limited data. However, 2,4-D degraded more rapidly under anaerobic conditions than aerobic conditions, which agrees with the results reported by Parker and Doxtader (20).

E. Groundwater monitoring

Information from the groundwater monitoring study will be used to establish a baseline concerning the extent of pesticide contamination of Arkansas groundwater.

Table 5. Concentration of triclopyr remaining in the constant temperature/water potential incubation study from GC/ECD analysis, Crowley silt loam soil.

0 m soil				
Weeks of incubation	15 C		30 C	
	0 kPa	100 kPa	0 kPa	100 kPa
	-----ppm-----			
0	4.58	4.48	4.18	4.45
1	3.90	4.50	4.01	3.73
2	4.29	4.23	2.97	3.08
4	4.47	4.16	2.55	2.17
0.2 m soil				
Weeks of incubation	15 C		30 C	
	0 kPa	100 kPa	0 kPa	100 kPa
	-----ppm-----			
0	5.37	5.30	5.15	5.17
1	5.37	4.96	4.69	4.86
2	5.18	4.97	4.44	4.09
4	5.21	4.86	4.15	3.86
0.6 m soil				
Weeks of incubation	15 C		30 C	
	0 kPa	100 kPa	0 kPa	100 kPa
	-----ppm-----			
0	5.39	5.10	5.26	5.30
1	5.39	4.64	4.25	4.23
2	5.61	5.34	4.47	5.33
4	5.25	5.30	4.49	4.97

Table 6. Estimated 2,4-D half-lives¹ in the constant temperature/water potential incubator study, Crowley silt loam soil.

Treatment	half-life	R ²
<u>0 m soil</u>		
	(days)	
15 C/0 kPa	8	0.87
15 C/100 kPa	23	0.99
30 C/0 kPa	3	0.95
30 C/100 kPa	6	0.99
<u>0.2 m soil</u>		
15 C/0 kPa	4	0.84
15 C/100 kPa	12	0.98
30 C/0 kPa	1	0.80
30 C/100 kPa	5	0.95
<u>0.6 m soil</u>		
15 C/0 kPa	25	0.96
15 C/100 kPa	47	0.93
30 C/0 kPa	27	0.94
30 C/100 kPa	35	0.88

¹Assuming First Order Kinetics.

CONCLUSIONS

Our studies indicate that triclopyr in soil dissipates rapidly in the field when stored in pits at 0 and 0.2 m depths. Triclopyr was more persistent at 0.6 m probably due to higher clay content, organic matter, and thus greater adsorption. However, these data indicate that probably of triclopyr actually reaching this depth in a typical rice field is low based on the rate of dissipation at the upper levels and the reduced water conductivity. If triclopyr reached 0.6 m, the higher adsorption values would probably further reduce the chance for ground water contamination. The relatively short half-lives of 2,4-D on 0 and 0.2 m Crowley silt loam soil indicates that the probability of 2,4-D reaching lower depths is unlikely. In general none of the rice herbicides with the exception of quinclorac evaluated in the simulated carryover study should present carryover problems to subsequent rotational crops in the year following rice production. Information from the groundwater monitoring study will be used to establish a baseline concerning the extent of pesticide contamination in Arkansas groundwater.

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