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This is a final project report submitted to the Organic Farming Research Foundation.

Project Title:

Plant mobilization of trace organochlorine residues

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Plant Mobilization of Trace Organochlorine Residues

Oregon Tilth CAAR Grant #93-227

Abstract

Organochlorine residues from past agricultural practices continue to pose problems for Oregon's growers. Even trace residues can affect product grown on contaminated soils. Oregon Tilth has undertaken a two year survey of plant uptake under field conditions with trace OC residues. While few crops uptake levels surpassing federal limits, many crops surpass organic standards for contaminant content. Rates of uptake vary significantly within and amongst crops tested. Uptake rates vary according to the amount of contaminant present, and vary according to type of contaminant. Test results also vary within a given sample. Still, certain plants show a propensity to uptake contaminants, while others appear safe to grow on soils with trace levels of OC contamination. This experiment demonstrates that carrots and squash are at risk crops for ground contaminated with chlordane. Carrots, cucumbers, melons, and squash are shown to be at risk crops for ground contaminated with dieldrin. Beans, broccoli, corn, lettuce, tomatoes, and peas appear low risk for ground contaminated with chlordane, dieldrin, or DDT.

Background:

Soil testing has long been a part of Organic Certification. As part of the certification process, each grower must submit soil tests for lab analysis. The soil is subjected to chromatography tests to determine the extent of contamination by organochlorine insecticides. These compounds classify a wide range of noxious agricultural pesticides, many with half lives exceeding twenty years. Unfortunately for conventional and organic growers, even at hardly detectable levels these contaminants are finding their way into agricultural products. The Food and Drug Administration has established levels for taking legal action to remove contaminated products Organic standards are five and ten percent of federal limits respectively for Oregon Tilth and Oregon's organic statutes.

Rates of plant concentration of soil contaminants are not well known. Many crops are not included in *the* surveys. Much of the information is based upon recent applications of a contaminant, not trace residues. How reliable are currently accepted rates of uptake? Are there trends within a crop, or within a crop type or family? And are there any safe crops to grow on contaminated soils? Over a two year period, seventeen annual vegetable crops were grown in a four block experiment to determine pesticide uptake. Following are the procedures, results, and discussion of this on-farm experiment. Two years of soil contaminant level tests and nutrient tests from the experiment are included.

[1] "Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed," Food and Drug Administration, Washington DC, 1987.

I. Methods and Procedures:

Procedure:

The experiment was conducted on sandy loam, Newburg soils in the Willamette Valley containing trace residues of chlordane, dieldrin, and DDT. An "on-farm" experiment, four blocks of twelve varieties in year one (eight in year two) were designed to allow for establishment and maintenance by farm machinery. Soil cores were taken to twelve inches to form a composite sample from each block, each year of the experiment. Different crops were planted to sections within the blocks, and randomly assigned to those sections. As plants came to maturity, composite tissue samples were taken from the edible portion of the plant and sent to Antech Labs in Corbett Oregon for analysis using solvent extraction, floricil cleanup, and electron capture gas chromotography.

Experiment establishment:

A four block design was used for the experiment Each block was ten feet wide (two tractor widths). The block was then divided into approximately sixty foot sections. In the first year, the blocks were ten sections long (600 feet). In the second year, the blocks were eight sections long (480 feet). The number of sections corresponded to the number of crops or "treatments" to be grown and tested. A random number generator was used to assign the crops to each section. Each block was fertilized with composted chicken manure and straw bedding at a rate of approximately four tons to the acre.

In both years, composite soil cores were taken from each block to a depth of twelve inches. These cores were individually analyzed for contaminant levels for each year of the experiment. A single composite of the entire plot was also sent in for nutrient analysis each year. An attempt was made to locate the experiment in the exact same location in the second year, but some shifting of beds occurred.

The sections were planted according to common plant densities. Each block was essentially two four foot beds wide, and crops were planted in one to three rows (60", 32", or 16" rows respectively) per bed: Beans (var. Provider) -3 rows/bed x 3", beets (var. Winter Keeper) - 3 x 3", broccoli (var. Pacman) - 2 x 12", carrots (var. Amsterdam) - 3 x 2", corn (var. Bodacious) -2 x 4", cucumber (var. Marketmore) - 1 x 24", lettuce (var. Valmaine) - 2 x 12", mustard (var. Green Wave) - 3 x 2", bunch onions (var. Tokyo Long) - 3 x 1", peas (var. Sugar Anne) -3 x 2",potatoes (var. Russet)- 2 x 14", radish (var. Red Ball) - 3 x 2", spinach (var. Space) - 3 x 3", squash winter (var. Baby Blue) -1 x 24", squash summer (var. Sunburst) -1 x 24", tomatoes (var. Siletz) - 2 x 18", watermelon (var. Moon and Stars) - 1 row/bed x 24". Lettuce, watermelon, tomato, summer squash, and broccoli were transplanted from starts. Transplants were grown in a peat moss, vermiculite, and compost potting mixture from four weeks (lettuce, summer squash, and broccoli) to eight weeks (tomato and melon) in the greenhouse. In 1994, all the plantings were complete by June. In 1995, because of late spring rains, planting was not complete till July.

The experiment was maintained organically, no preventative or remedial chemical or other treatment was given to any of the sections. In the first year carrots, broccoli and potatoes failed to produce good samples. In the second year, summer squash did not produce two of the four samples (blocks I and II).

Sampling:

Soil cores were taken to a depth of 12 inches from each of the four blocks in both years with a shovel from at least eight points throughout each block. Soil nutrient samples were compiled from the block samples. Crop samples were made at point of maturity for each section. Excepting were the radishes which had grown woody and begun to bolt. Summer squash samples were "baby" squash, with fruit ranging from one to three inches. Carrot samples ranged from baby to mature carrots. All samples were taken from several points throughout each section. Fruit was sliced from cucumbers, watermelons, and winter squash in order to obtain a more representative sample.

Testing:

All soil and tissue tests were performed by Antech Labs of Corbett, Oregon. Samples were analyzed for organochlorine content using gas chromatography. Detection limits were 0.00 1 parts per million (chlordane 0.005 ppm, toxaphene 0.01 ppm). Compound included in analysis were: aldrinb, BHC, chlordane, chlorpropham, DDT and metabolites, dieldrin, endosulfan, endrin, ethylan, HCB, heptachlor, heptachlor epoxide, lindane, methoxychlor, mirex, nitrofen, oves, PCB's, quintozene, and toxaphene. Spiked duplicate samples were run for tissue and soil samples, with recovery percentages ranging from 61 % to 112% (see appendix). Duplicate samples were spiked with a known quantity of dieldrin. Dieldrin from original samples was subtracted from results, and recovery rates were determined.

Procedure notes, tissue samples: (methodology: PAAM 212)

Samples were thoroughly comminuted and representative samples were taken for analysis. 100 gram samples were extracted with acetone, filtered, and partitioned with water into petroleum ether. After removing traces of water from petroleum ether extract, samples were concentrated. Petroleum ether concentrate was placed on florosil (silica gel) columns and eluted into two petroleum ether/ethyl ether fractions. Fractions were concentrated and injected into the gas chromatograph fitted with a non polar wide bore capillary column (J&W DB5) and anelectron capture detector. The confirmation column was a non polar wide bore capillary column (J&W DB1701).

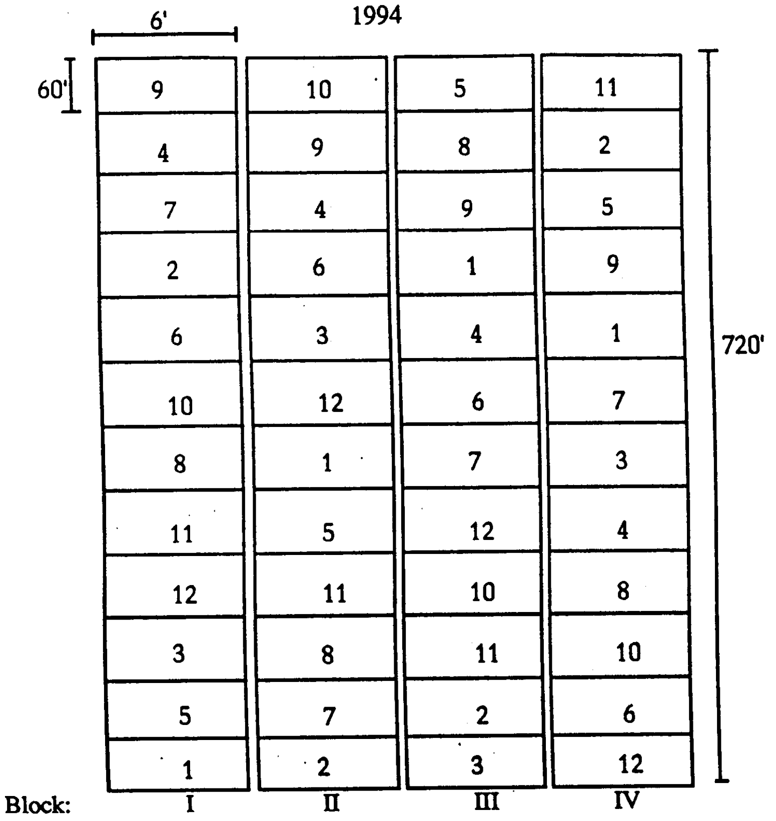
Procedure notes, soil samples: (methodology: EPA 8081, AOAC 970.52 (15th ed])

Samples were thoroughly comminuted and representative samples were taken for analysis, Samples were extracted overnight into hexane/acetone in a soxhiet extractor. Extracted sample was partitioned with water into hexane. Water free hexane was concentrated. Concentrated hexane was placed on a florosil column and eluted with two petroleumether/ethyl ether fractions. Fractions were concentrated and injected into GC as with tissue samples.

Spiked duplicate samples:

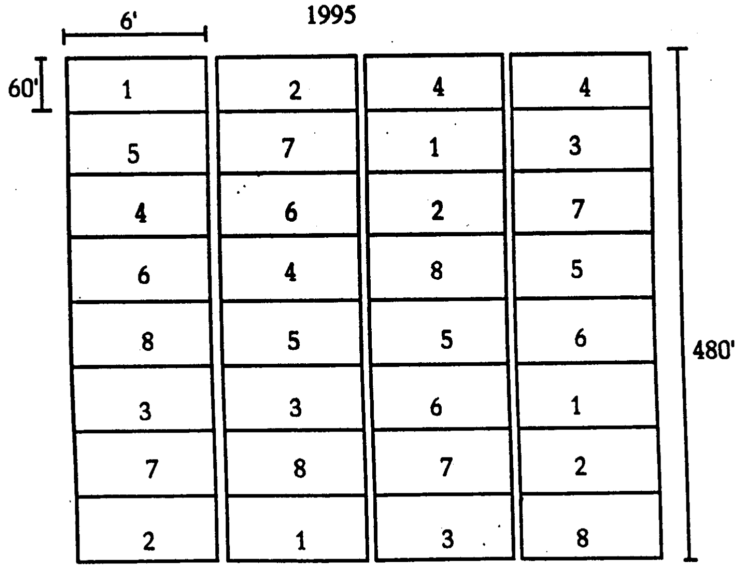
In year one, duplicate samples were run for one sample within each crop and one soil sample.., . Duplicate samples are spiked with a known quantity of dieldrin. Dieldrin from the original samples is subtracted from the results from the duplicate sample, and a recovery percentage is determined Spiked duplicate samples were not performed for year two samples, or for corn in year one.

PLOT DIAGRAMS:



	9	10	5	11
	4	9	8	2
	7	4	9	5
	2	6	1	9
	6	3	4	1
	10	12	6	7
	8	1	7	3
	11	5	12	4
	12	11	10	8
	3	8	11	10
	5	7	2	6
	1	2	3	12
Block:	I	II	III	IV

1: Bean green
2: Carrot
3: Potato
4: Beet
5: Corn
6: Melon water
7: Cucumber
8: Squash
9: Lettuce
10: Broccoli
11: Tomato
12: Radish



1	2	4	4
5	7	1	3
4	6	2	7
6	4	8	5
8	5	5	6
3	3	6	1
7	8	7	2
2	1	3	8

1: Potato
2: Carrot
3: Spinach
4: Gr. Onion
5: Snap Peas
6: Zucchini
7: Broccoli
8: Mustard

Table 1

Results of pesticide uptake survey 1994: parts per million (ppm)

	Block I	Block II	Block III	Block IV	mean
Soil					
chlordane	0.122	0.143	0.126	0.109	0.125
dieldrin	0.003	0.003	0.004	0.003	0.0034
DDT	0.078	0.0	0.056	0.1	0.058
Beans					
chlordane	0.002	0.0	0.0	0.0	0.0005
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.0	0.0	0.0	0.0
Beets					
chlordane	0.006	0.0	0.007	0.009	0.0055
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.001	0.002	0.001	0.0	0.001
Beet greens					
chlordane	--	--	--	0.017	
dielrin	--	--	--	trace	
DDT	--	--	--	0.0	
Corn					
chlordane	0.0	0.0	0.0	0.0	0.0
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.0	0.0	0.0	0.0
Cucumber					
chlordane	0.018	0.015	0.016	0.043	0.023
dieldrin	0.004	0.003	0.001	0.0	0.002
DDT	0.0	0.0	0.0	0.0	0.0
Lettuce					
chlordane	0.0	0.0	0.0	0.0	0.0
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.003	0.0	0.0	0.0	0.0008
Melon					
chlordane	0.009	0.016	0.016	0.014	0.0138
dieldrin	0.0	0.029	0.001	0.0	0.0075
DDT	0.0	0.0	0.0	0.0	0.0
Radish					
chlordane	0.0	0.0	0.037	0.012	0.0123
dieldrin	0.0	0.0	0.0	0.002	0.0005
DDT	0.0	0.0	0.0	0.0	0.0
Squash winter					
chlordane	0.06	0.118	0.007	0.12	0.0763
dieldrin	0.005	0.011	0.005	0.005	0.0065
DDT	0.0	0.0	0.0	0.0	0.0
Squash seed					
chlordane	0.052	0.087	0.06	0.038	0.059
dieldrin	0.015	0.0	0.001	0.005	0.0053
DDT	0.0	0.0	0.0	0.0	0.0
Tomato					
chlordane	0.0	0.0	0.0	0.0	0.0
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.0	0.0	0.0	0.0

II. Results

Standard deviation and significance tests were run at Oregon State University for results of both years (see appendix). In regards to uptake of chlordane: Carrots, squash and, squash seeds significantly differ from all other crops. Cucumbers, melons, squash, squash seeds, and carrots significantly differ from all other crops with regard to dieldrin uptake. Carrots and potatoes significantly differed from all other crops in regards to DDT uptake. Significance tests were run at 10% and 5% LSD (least significant difference).

Residues at some detectable level were present in the following crops: beans, beets, carrots, cucumbers, lettuce, melons, mustard, green onions, potatoes, radishes, spinach, winter and summer squash. The only crops that came up clean of all residue were: broccoli, corn, peas, and tomato. Lettuce only took up three thousandths ppm DDT in one block. Beans also only registered two thousandths ppm chlordane in one block. Both of these examples exceed the statistical accuracy of the testing equipment's' recovery capacity for these contaminants. (A spiked duplicate sample of beans showed 69% accuracy, lettuce at 61%, with limits at.001 ppm.)

No crop exceeded the federal action limits for any of the contaminants when the averages from the four blocks were considered. In block II the level of chlordane in carrots reached federal limits (0.1 ppm), and in block IV approached the limit (0.97 ppm). In block H and block IV, winter squash <u>surpassed</u> federal action limits for chlordane. No other crops approached federal action limits in any of the four blocks for any contaminant.

Several crops surpassed organic limits of contaminant content. Beets, beet greens, cucumber, melon, potatoes, green onions, spinach, and summer squash exceeded organic standards for chlordane content. Melons, carrots, mustards, and winter squash exceeded organic limits for dieldrin content. When the ten percent of federal limits standard (as with Oregon's organic Rule) was applied, beets, potatoes and spinach did not exceed organic limits.

Rates of uptake differed substantially for all crops where uptake rates existed in the literature. Only the concentration ratio of chlordane for beans was comparable with the rate given for legumes in the literature (0.004 v. 0.005). Interestingly, the rate given in the literature for beans was based on soil rates even less than soil rates for the experiment (0.02 < 0.125). Wherever rates of concentration were available for chlordane in the literature, the actual rates found were less. In the instance of peas, no rate of uptake for chlordane was found. In crops susceptible to trace dieldrin uptake, rates of concentration were substantially higher than rates given in the literature. In some cases, because of the low rates of dieldrin in the soil, some crops appeared to dramatically concentrate levels in the ` soil (squash 2 x, melon 2 x, green onions 10 x, carrot 120 x, mustard 50 x). In the case of beans, corn, lettuce, and peas no dieldrin uptake was found, despite the literature suggesting otherwise. When DDT rates were given in the literature, actual rates found were greater when the literature used rates based on high soil rates. When the literature's source rates approximated trace residues, the actual rates found were lower.

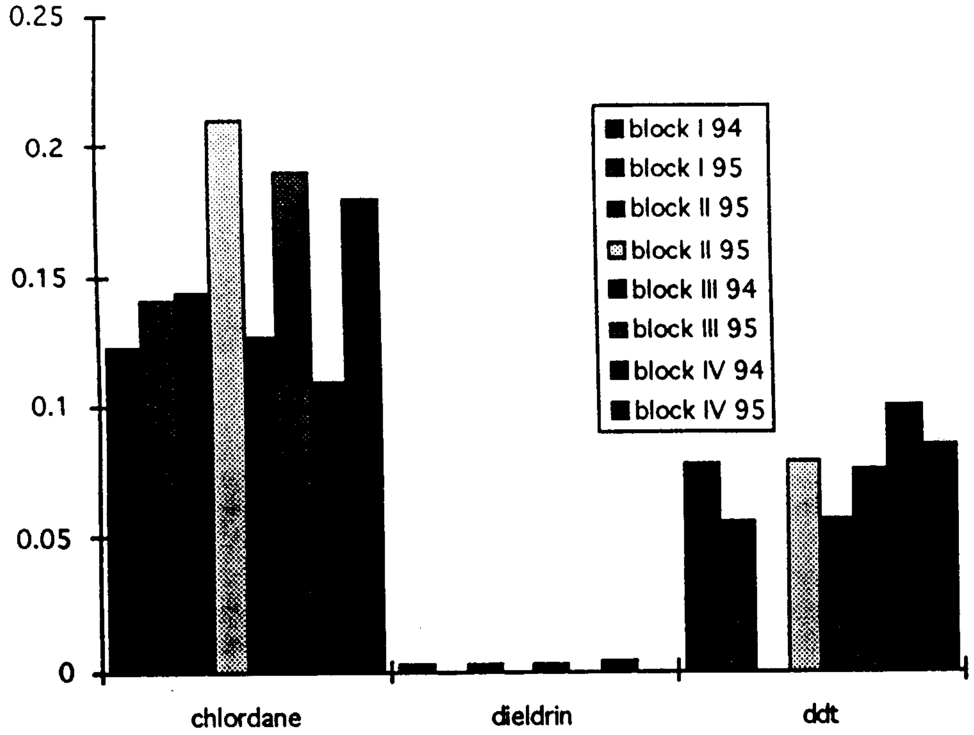
When variance between blocks of crops is correlated to variance between soil blocks no pattern emerges. In a casual analysis of year one chlordane residues in tissue and soil, squash seeds is the only example where residue levels in tissue reflect the various residue levels of the composite soil samples. In year two, chlordane residues in carrots was the only crop to correlate to soil residues of chlordane. Trying to correlate higher residues to one end or the other of the entire plot demonstrates no recognizable pattern for any contaminant. Multiplying soil residues by the mean uptake ratio for a given crop in year one for chlordane results in similar average uptake rates, but specific rates for a given block show no consistency.

Table 2

Results of pesticide uptake survey 1995

	Block I	Block II	Block III	Block IV	mean
parts per million					
Soil					
chlordane	0.14	0.21	0.19	0.18	0.18
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.055	0.079	0.076	0.085	0.074
Broccoli					
chlordane	0.0	0.0	0.0	0.0	0.0
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.0	0.0	0.0	0.0
Carrot					
chlordane	0.027	0.1	0.041	0.097	0.0663
dieldrin	0.031	0.006	0.005	0.0	0.0105
DDT	0.0	0.011	0.002	0.0	0.0033
Mustard					
chlordane	0.004	0.0	0.007	0.008	0.0048
dieldrin	0.001	0.0	0.0	0.001	0.005
DDT	0.0	0.0	0.0	0.0	0.0
Peas					
chlordane	0.0	0.0	0.0	0.0	0.0
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.0	0.0	0.0	0.0
Potatoes					
chlordane	0.002	0.0	0.023	0.004	0.0073
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.001	0.002	0.0	0.0008
Onions bunching					
chlordane	0.005	0.0	0.013	0.028	0.0115
dieldrin	0.002	0.0	0.001	0.001	0.001
DDT	0.0	0.0	0.0	0.0	0.0
Spinach					
chlordane	0.016	0.0	0.004	0.005	0.0063
dieldrin	0.0	0.0	0.0	0.0	0.0
DDT	0.0	0.0	0.0	0.0	0.0
Squash Summer					
chlordane	--	--	0.046	0.031	0.0385
dieldrin	--	--	0.0	trace	0.0
DDT	--	--	0.0	0.0	0.0

Table 3
Pesticide levels in four blocks 1994 and 1995 (ppm)

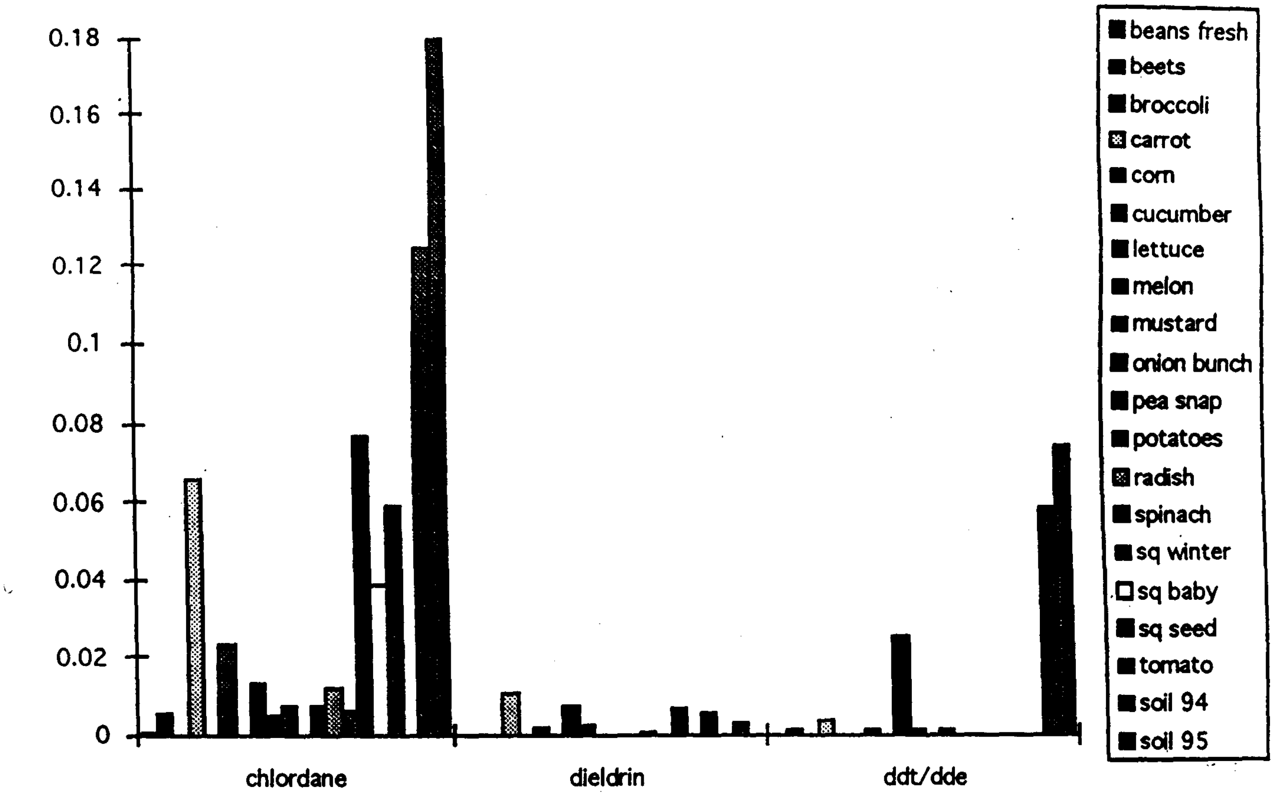


Chlordane soil levels varied between blocks, and from year to year. In year two, all soil rates of chlordane were proportionally higher than year one. Dieldrin rates were consistent within the first year, and in the second year no soil dieldrin levels registered. DDT rates were fairly consistent year to year, and amongst the four blocks. Block II of year one registered no DDT, rendering any correlation statistically insignificant. The low rates of dieldrin in both years may have contributed to the concentrating ratio of uptake by susceptible crops.

A spiked duplicate sample run on block four in year one, registered 0.075 ppm chlordane compared to 0.109 ppm chlordane from the same sample. In year two, the sample from that block registered 0.18 ppm chlordane. Each of these variances exceeds the estimated percentage of recovery (85% of spiked dieldrin) for the testing equipment and procedures.

Soil samples were taken in the spring of year one, and in the fall of year two. Higher or lower rates of contaminant registered in the soil may have been affected by mixing of the soil in tillage, higher rates of biological activity, or two years of intensive cropping on previously fallowed ground. The failure to detect dieldrin in soil samples of year two did not result in no detected residues of dieldrin in crops grown the second year.

Table 4
Pesticide uptake by 18 crops and soil levels 1994, 1995 (ppm)



From Table 4 it is not obvious that the more contaminant present in the soil, the higher the level of plant uptake. While DDT levels are substantially higher than dieldrin levels in the soil, more crops are apt to absorb dieldrin into their tissues than DDT. While crops registering chlordane levels appear likely to absorb dieldrin, crops absorbing DDT show little correlation to dieldrin or chlordane uptake.

Lower levels of dieldrin present in the soil give the impression that crops are actually concentrating soil residues in the tissue of the plant. The lack of dieldrin detected in the soils in year two accentuates this observation. It is not clear if this is indicative of plants propensity to adsorb dieldrin, or a trend of plants to adsorb even the tracest residues into their tissue.

Table 5

Average uptake by crops and federal and organic limits

1994 crop (parts per million)	mean uptake	Federal limit	Organic* limit
Beans			
chlordane	0.0005	0.1	0.005
dieldrin	0.0	0.05	0.0025
DDT	0.0	0.2	0.01
Beets			
chlordane	**0.0055**	0.1	0.005
dieldrin	0.0	0.1	0.005
DDT	0.001	0.2	0.01
Beet greens			
chlordane	**0.017**	0.1	0.005
dielrin	trace	0.05	0.0025
DDT	0.0	0.2	0.01
Corn			
chlordane	0.0	0.1	0.005
dieldrin	0.0	--	
DDT	0.0	0.1	0.005
Cucumber			
chlordane	**0.023**	0.1	0.005
dieldrin	0.002	0.1	0.005
DDT	0.0	0.1	0.005
Lettuce			
chlordane	0.0	0.1	0.005
dieldrin	0.0	0.03	0.0015
DDT	0.0008	0.5	0.025
Melon			
chlordane	**0.0138**	0.1	0.005
dieldrin	**0.0075**	0.1	0.005
DDT	0.0	0.1	0.005
Radish			
chlordane	**0.0123**	0.1	0.005
dieldrin	0.0005	0.1	0.005
DDT	0.0	0.2	0.01
Squash winter			
chlordane	**0.0763**	0.1	0.005
dieldrin	**0.0065**	0.1	0.005
DDT	0.0	0.1	0.005
Squash seed			
chlordane	0.059	--	
dieldrin	0.0053	--	
DDT	0.0	--	
Tomato			
chlordane	0.0	0.1	0.005
dieldrin	0.0	0.05	0.0025
DDT	0.0	0.05	0.0025

*Oregon Tilth's standards of organic certification (1/20th federal limit)

Table 5 continued

1995

crop (parts per million)	**mean uptake**	**Federal limit**	**Organic* limit**
Broccoli			
chlordane	0.0	0.1	0.005
dieldrin	0.0	0.03	0.0015
DDT	0.0	0.5	0.025
Carrot			
chlordane	**0.0663**	0.1	0.005
dieldrin	**0.0105**	0.03	0.0015
DDT	0.0033	3	.15
Mustard			
chlordane	0.0048	0.1	0.005
dieldrin	**0.005**	0.05	0.0025
DDT	0.0	0.5	0.025
Peas			
chlordane	0.0	0.1	0.005
dieldrin	0.0	0.05	0.0025
DDT	0.0	0.2	0.01
Potatoes			
chlordane	**0.0073**	0.1	0.005
dieldrin	0.0	0.1	0.005
DDT	0.0008	1	0.05
Onions bunching			
chlordane	**0.0115**	0.1	0.005
dieldrin	0.001	--	
DDT	0.0	--	
Spinach			
chlordane	**0.0063**	0.1	0.005
dieldrin	0.0	0.1	0.005
DDT	0.0	0.5	0.025
Squash Summer			
chlordane	**0.0385**	0.1	0.005
dieldrin	0.0	0.1	0.005
DDT	0.0	0.1	0.005

*Oregon Tilth's standards of organic certification (1/20th federal limit)

Table 6

Movement of Insecticides from Soil into Plants:

	Anticipated from Literature*			Actual		
	Residue (ppm)			Residue (ppm)		
crop	amount in source	amount in plant	conc. or dilut.**	amount in source	amount in plant	concen. or dilution factor
Beans						
chlordane	0.02	<0.0001	0.005	0.125	0.0005	0.004
dieldrin	0.05	0.0025	0.05	0.003	0.0	0.0
DDT	0.57	0.042	0.074	0.058	0.0	0.0
Beets						
chlordane	1.233	0.224	0.182	0.125	0.0055	0.044
dieldrin	0.35	0.101	0.284	0.003	0.0	0.0
DDT	1.537	0.103	0.067	0.058	0.001	0.017
Beet greens						
chlordane	na	na	na	0.125	0.017	0.136
dielrin	na	na	na	0.003	<0.0001	0.029
DDT	na	na	na	0.058	0.0	0.0
Corn						
chlordane	na	na	na	0.125	0.0	0.0
dieldrin	0.48	0.11	0.229	0.003	0.0	0.0
DDT	na	na	na	0.058	0.0	0.0
Cucumber						
chlordane	na	na	na	0.125	0.023	0.184
dieldrin	1.4	0.043	0.031	0.003	0.002	0.666
DDT	na	na	na	0.058	0.0	0.0
Lettuce						
chlordane	na	na	na	0.125	0.0	0.0
dieldrin	2.3	0.03	0.013	0.003	0.0	0.0
DDT	na	na	na	0.058	0.0008	0.013
Melon						
chlordane	na	na	na	0.125	0.0138	0.11
dieldrin	na	na	na	0.003	0.0075	2.5
DDT	na	na	na	0.058	0.0	0.0
Radish						
chlordane	na	na	na	0.125	0.012	0.096
dieldrin	na	na	na	0.003	0.0005	0.166
DDT	na	na	na	0.058	0.0	0.0
Squash winter						
chlordane	na	na	na	0.125	0.076	0.61
dieldrin	na	na	na	0.003	0.0065	2.16
DDT	na	na	na	0.058	0.0	0.0
Squash seed						
chlordane	na	na	na	0.125	0.059	0.472
dieldrin	na	na	na	0.003	0.0053	17.66
DDT	na	na	na	0.058	0.0	0.0
Tomato						
chlordane	na	na	na	0.125	0.0	0.0
dieldrin	na	na	na	0.003	0.0	0.0
DDT	na	na	na	0.058	0.0	0.0

* Adapted from Persistent Pesticides in the Environment, C.A. Edwards, Cleveland, Ohio, 1973.

** Concentration of dilution factor = amount in plant / amount in soil.

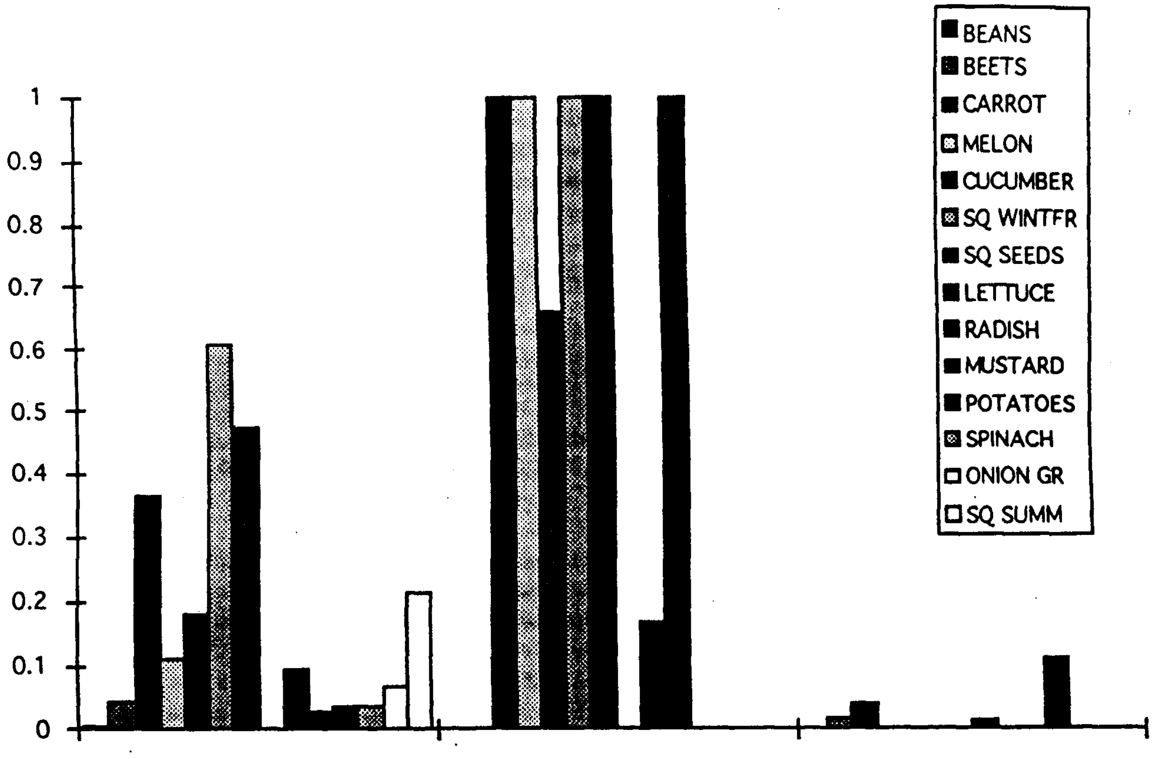
Table 6 continued

1995

	Anticipated from Literature*			**Actual**		
	Residue (ppm)			**Residue (ppm)**		
crop	**amount in source**	**amount in plant**	**conc. or dilut.****	**amount in source**	**amount in plant**	**concen. or dilution factor**
Broccoli						
chlordane	na	na	na	0.18	0.0	0.0
dieldrin	na	na	na	0.0 (<0.001)	0.0	0.0
DDT	na	na	na	0.074	0.0	0.0
Carrot						
chlordane	na	na	na	0.18	0.066	0.366
dieldrin	1.165	0.0046	0.039	0.0	0.012	120
DDT	4.90	0.037	0.007	0.073	0.003	0.041
Mustard						
chlordane	na	na	na	0.18	0.005	0.027
dieldrin	na	na	na	0.0	0.005	50
DDT	na	na	na	0.074	0.0	0.0
Peas						
chlordane	0.02	<0.0001	0.0005	0.18	0.0	0.0
dieldrin	0.05	0.0025	0.05	0.0	0.0	0.0
DDT	na	na	na	0.074	0.0	0.0
Potatoes						
chlordane	na	na	na	0.18	0.007	0.038
dieldrin	na	na	na	0.0	0.0	0.0
DDT	24.8	1.63	0.066	0.074	0.008	0.108
Onions bunching						
chlordane	na	na	na	0.18	0.012	0.066
dieldrin	na	na	na	0.0	0.001	10
DDT	na	na	na	0.074	0.0	0.0
Spinach						
chlordane	na	na	na	0.18	0.0063	0.035
dieldrin	na	na	na	0.0	0.0	0.0
DDT	na	na	na	0.074	0.0	0.0
Squash Summer						
chlordane	na	na	na	0.18	0.0385	0.213
dieldrin	na	na	na	0.0	0.0	0.0
DDT	na	na	na	0.074	0.0	0.0

* Adapted from Persistent Pesticides in the Environment, C.A. Edwards, Cleveland, Ohio, 1973.
** Concentration of dilution factor = amount in plant / amount in soil

Table 7
Actual rates of contaminant concentration by 13 crops*



***those values greater than one were assigned the value of one for legibility of the graph**

III. Discussion

From the results it is clear that some crops are at risk of pesticide uptake. Carrots, cucumbers, melons, radishes, squash, and mustard are statistically significant at risk crops for ground with any residues of chlordane or dieldrin. Spinach, beets and onions appear to be at risk crops for ground with chlordane residues. Those crops susceptible to dieldrin uptake also appear sensitive to chlordane uptake, though not vice versa. This observation is possibly due to the low levels of dieldrin in the soil. Potatoes and beets appear to be at risk crops for ground contaminated with DDT. Carrots appear to be the only at risk crop for ground containing chlordane, dieldrin, or DDT. While DDT and dieldrin soil levels are very low, there is a much stronger correlation between crops susceptibility to chlordane and dieldrin, than to DDT.

Crops that appear safe to grow on ground with trace contaminants of organochlorine insecticides include beans, broccoli, corn, lettuce, peas, and tomatoes. Potentially safe crops include beets (without the greens), mustard, green onions, potatoes, and spinach. These crops barely surpass organic standards, and if the statistical reliability of the testing equipment were figured in, they would be safe for organic growers. Still, they pose a risk, especially for ground with higher levels of contaminant. Melons, cucumbers, radishes, and beet greens appear safe for conventional growers with trace contaminants, but would be off limits for organic growers even under a ten percent standard. Radishes deserve some discussion, due to the condition of the samples. Since the radish samples were overgrown, it was impossible to eliminate all of the soil particles. This may have substantially contributed to their apparent high rate of uptake.

It is important to consider that squash and carrots were the only crops found to have statistical significance compared to all other crops regarding chlordane uptake. While other crops may have registered chlordane residues, there is no reliability that their uptake will significantly differ from zero in any subsequent test. Cucumber, melon, squash, and carrots demonstrated significant difference form all other crops regarding dieldrin uptake. From this experiment it can be said that carrots and squash are statistically significant at risk crops on chlordane contaminated soils. The same can be said for carrots, cucumbers, melons, and squash on dieldrin contaminated soils. Though some crops registered no levels of any contaminant, their difference from other low levels were not significant enough to suggest statistical reliability.

Rates of uptake seem to favor low levels of contaminant. For sensitive crops, the lower level of contaminant in the soil, the higher the uptake ratio. Mustards, carrots, and green onions appeared to concentrate dieldrin in their tissues, even though no dieldrin was found in the soil sample for that year (in the previous year 0.003 ppm dieldrin was found). This suggests that soils with a clean bill of health one year may produce crops with levels of contaminant exceeding organic standards. Currently, tissue tests are generally taken only on farms with known soil contaminants, though random testing of shelf product does occur. Reliability of uptake ratios for differing soils are not possible to determine from this type of experiment. Ratios given in the literature did not match actual ratios, except in the case of beans (which were at extremely low levels of uptake).

Families of plants appear to correlate with regards to their susceptibility to contaminant concentration. The cucurbits (cucumbers, melons, squash) appear to be at greatest risk for uptake. The chenopods (beets and spinach) and the brassicas (radish and mustards) also appear to have a propensity to draw contaminants from the soil. Except, the broccoli (a brassica) appears to be impervious to contaminant uptake. Interestingly both Brassicaceae and Cucurbitacea are of the same superorder Violanae. While-carrots, radishes, and potatoes all demonstrate some uptake, their similarity may have more to do with the difficulty of completely eliminating the soil from the samples than the propensity of root crops to uptake contaminant Legumes (beans and peas) appear to produce edible portions safe from contaminants, though their roots have been found to contain large amounts of recently applied contaminants.'

Spiked duplicate samples run for each of the crops grown in year one demonstrate a statistical reliability from 61% to 112%. The same samples tested twice with the same equipment often varied greater than the statistical reliability would suggest. The highest ` levels of statistical reliability were for the crops with the highest concentration ratios in the first year (melons, cucumbers, and squash: 97%). Most of the organic limits for contaminant content approach the testing limits (.0001) of the the equipment. To figure in the statistical reliability of the equipment suggests that on any given crop, grown on any given soil, there is a risk surpassing organic standards.

Organochlorine contaminants are pervasive in our environment Most class I and II agricultural soils have been in production for some time, and have probably had some exposure to organochlorine contaminants. Though they are not recognized for their solubility or volatility, identifiable levels of OC contaminants have been found on nonagricultural ground, even in remote locations throughout the world. Certain crops appear to be very sensitive to even the tracest quantities of OC contaminants. Other crops appear to leave them in the soil. Soil tests may not be indicative of plant uptake: Ground with no apparent contamination may produce contaminated crops. Trace residues appear to act differently than higher concentrations of contaminants. Plants appear to have differing susceptibilities to different organochlorines (with dieldrin perhaps the most likely to concentrate in plant tissue). The same sample of soil or plant tissue may produce results differing greater than the statistical reliability of the testing equipment Growing "clean" food may require restricting our diets to only certain crops, even on "clean" soil.

' Persistent Pesticides in the Environment, C.A. Edwards, Cleveland, Ohio, 1973.

```
11-21-95 (RESHAP.DAT)                                          SUMMARY Page 2
                           Oregon State University
Project Code:                        Location    :
Cooperator  :                        By:Dr. J. Pscheidt

Pathogen Code                         chlordan   dieldrin        ddt
Rating Unit                                ppm        ppm        ppm
-----------------------------------------------------------------------------
 Trt Treatment       Form      Grow
 No  Name            Amt  Rate Stg
=============================================================================
  1  Carrot                          0.0663 a   0.0105 a   0.0033 a
  2  Spinach                         0.0063 b   0.0000 b   0.0000 b
  3  Mustard                         0.0048 b   0.0005 b   0.0000 b
  4  Peas                            0.0000 b   0.0000 b   0.0000 b
  5  Potatoes                        0.0073 b   0.0000 b   0.0008 ab
  6  Onion                           0.0115 b   0.0010 b   0.0000 b

 LSD (.05)     =                     0.0263     0.0085     0.0032
 Standard Dev.=                     .017455    .005626    .002153
 CV            =                     109.09     281.27     322.88

 Block F                              0.722      1.152      1.151
 Block Prob(F)                       0.5543     0.3606     0.3608
 Treatment F                          8.139      2.212      1.460
 Treatment Prob(F)                   0.0007     0.1072     0.2602

Means followed by same letter do not significantly differ (P=.05, LSD)

                           - End of Report -
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-7-94 (RESHAP.DAT)                                                          SUMMARY Page 3
                              Oregon State University
               Evaluation of residue uptake of 8 different crops.
oject Code:                                       Location     :Heron's Nest Farm
operator   :JJ Haapala                            By:Dr. J. Pscheidt

thogen Code                          chlordan   dieldrin       DDT        DDT
ting Date                            09-13-94   09-13-94   09-13-94   09-13-94
ting Data Type                            ppb        ppb        ppb        ppb
ting Unit                                                   p'p'dde    p'p'dde
st Subspecies                                               o'p'ddt    o'p'ddt
st Stage at Eva                                             p'p'ddt    p'p'ddt
st Population                        w/o radi   w/o radi   w/o radi   w/o radi
ulation Unit                                                          w/o rep2
-------------------------------------------------------------------------------
t Treatment         Form        Grow
  Name              Amt  Rate   Stg
===============================================================================
  Beans                               0.5 c      0.0 b      0.0 b      0.0 b
  Beets                               5.5 c      0.0 b      1.0 b      0.7 b
  Watermelon                         13.8 c      7.5 a      0.0 b      0.0 b
  Cucumber                           23.0 c      2.0 ab     0.0 b      0.0 b
  Squash                             76.3 b      6.5 ab     0.0 b      0.0 b
  Squash Seeds                       59.3 b      5.3 ab     0.0 b      0.0 b
  Lettuce                             0.0 c      0.0 b      0.8 b      1.0 b
  Tomato                              0.0 c      0.0 b      0.0 b      0.0 b
  Radish
  Soil                              125.0 a      3.3 ab    58.5 a     78.0 a

D (.10)     =                        24.4        6.6       17.3       10.5
andard Dev.=                         20.1762     5.44437   14.3374    7.37833
            =                        59.88     200.00     214.17      83.35

ock F                                 1.171      0.946      0.983      0.952
ock Prob(F)                           0.3414     0.4341     0.4172     0.4069
eatment F                            19.014      1.247      7.347     37.061
eatment Prob(F)                       0.0001     0.3158     0.0001     0.0001

ns followed by same letter do not significantly differ (P=.10, LSD)

                              - End of Report -
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