SOIL AND GROUND WATER CONTAMINATION BY CITRUS SELECTIVE RESIDUAL HERBICIDES

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SUMMARY

Soil and well water samples, from citrus orchards, have been collected and analyzed for atrazine, bromacil, diuron, terbuthylazine, terbumetone, terbutryn and trifluralin.

Bioassays were made for two soil orchards from California (USA). Gas and liquid chromatography were used for soil and water samples from several Spain citrus orchards. Also oat bioassay was employed in some soils.

The results show that herbicides are concentrated on the upper soil layers, even after more than twenty years of continuous applications. There are no herbicide accumulations at any soil depths. Atrazine, bromacil, terbutylazine and terbumetone are the herbicides found in irrigation wells. In some circumstances, the concentration is above the maximum allowable concentration of the EC drinking water directive.

OBJECTIVE

To assess the soil and well water contamination by some citrus selectives herbicides in long term non tillage orchards.

METHOD

Samples of soil, at various depths and irrigation well water (see table of irrigation characteristics) were taken in several orchards on different dates.

The residual herbicides used were atrazine, bromacil, diuron, simazine, terbuthylazina, terbumetone, terbutryn and trifluralin.

Herbicide residual contents in soil and water were measured by G.L.C., (1, 3, 4, 5), H.P.L.C., (2) and by bioassays.

RESULTS

The results appeared in the following tables (Table 1, Table 2, Table 3 & Table 4) herbicides concentration (mg Kg^{-1}) in the soil samples taken at the Benifayo orchard levels of phytotoxicity by bioassay (*Avena sativa* L.) in Benifayo orchard herbicide concentration (mg Kg l^{-1}) in the soil samples taken in an orchard of Jativa, where only s-triazine residual herbicides were used. Herbicide concentration ($\mu g\ l^{-1}$) in samples taken in the Benifayo well.

CONCLUSIONS

1. Herbicide concentration in orchard soils of long term non tillage management did not build up in any soil level studied.
2. The depths that residual selective herbicides reach vary according to the following factors:
   2.1 Soil characteristics (mainly texture & organic matter).
   2.2 Volume and frequency of water (rain & method of irrigation).
   2.3 Chemical and physical herbicide properties.
3. After heavy rains or high volume irrigation, some of these herbicides appear in shallow wells. This occurs more frequently in the case of light textured soils, with some of the concentrations being above the drinking limit of E.E.C. (0.1 $\mu g/l^{-1}$).

4. Exactly how herbicides find access to these wells is not known, but it would seem to be, through preferential pathways.

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IRRIGATION WELLS CHARACTERISTICS

			WELLS			CHEMICAL ANALYSIS (2)			
Location	Province of	Orchards Irrigated by	number	depth (m)	Drilled in a soil with the first layer of	E.C.	pH	Cl- mg/l	No3- mg/l
Benifayo	Valencia	Flood	1	15	Sandy soil	2.1	7.3	110	268
Nules	Castellan	Flood	15	15	Loam soil	1.8	7.6	131	188
Jativa	Valencia	Micro sprinkler	4	50	Sandy soil	0.9	7.1	12	115
Ayamonte	Huelva	Drip	3	30-45	Sandy loam	0.4	7.1	99	9

(1) The wells selected where those known to have a concentation higher than 150 $\mu g\ l^{-1}$

(2) Average in the wells in each location

TABLE 1. HERBICIDE CONCENTRATION (mg kg^{-1}) IN SOIL SAMPLES TAKEN AT THEBENIFAYD ORCHARD.

Depth (cm)	Atra.	Sim.	Ter.Cl	Ter.O	Ter.S	Diu.	Brom.	Tri
0-30	0.02	0.04	0.08	0.11	0.06	0.08	0.01	0.06
30-60	0.01	0.02	0.01	0.01	<0.01	<0.04	<0.01	<0.01

*trifluralin was herbigated three months before sampling. Atra. = atrazine; Sim = simazine; Ter.Cl = terbuthylazine; Ter.O = terbumeton; Ter.S = terbutryn; Diu. = diuron; Brom. = bromacil; Trif.= trifluralin.

TABLE 2 Levels of Phytotoxicity by Bioassay (*Avena sativa* L.) in Benifayo Orchard

Depth (cm)	Orchard management	
	Non tillage	Tillage (*)
0-30	0.26 ± 0.04	1.50 ± 0.16
30-60	0.75 ± 0.11	1.59 ± 0.25

Values are fresh weight (in g) of the five plants per pot (mean ± standard deviation of 4 replicas). The tillage soil was taken in an orchard nearby in which no residual herbicides were used.

TABLE 3 Herbicide concentration (mg Kg-1) in the soil samples taken in an orchard of Jativa, where only S-Triazine residual herbicides were used.

Depth in cm.	Atra.	Sim.	Ter. Cl	Ter.O	Ter.S.
(a) samples taken in July 1989 before a heavy rainy period					
0-10	0.30	0.05	0.08	0.06	0.01
10-20	0.04	0.01	0.03	0.02	<0.01
20-30	0.03	<0.01	0.02	0.01	<0.01
30-40	0.01	<0.01	0.01	<0.01	<0.01
(b) samples taken in February 1990 after the heavy rainy period					
0-10	<0.01	0.02	0.03	0.04	0.01
10-20	<0.01	<0.01	0.02	0.03	<0.01
20-30	<0.01	<0.01	0.02	0.03	<0.01
30-40	<0.01	<0.01	0.02	0.02	<0.01
40-50	<0.01	<0.01	0.01	0.01	<0.01
50-70	<0.01	<0.01	<0.01	0.01	<0.01
70-90	<0.01	<0.01	<0.01	0.01	<0.01

Atra. = atrazine; Sim. = simazine; Ter. Cl = terbuthylazine; Ter. D = terbumeton; Ter.S. = terbutryn.

TABLE 4 Herbicide Concentration (ug/1) in samples taken in the Benifayo Well

Date of sampling	Atra.	Brom.	Sim.	Ter.Cl	Ter.O	Trif.
VI/17/89	1.2	4.4	n.d.	1.8	6.3	4.1
II/15/90	n.d.	19.4	n.d.	1.3	4.5	n.d.
VII/3/90	n.d.	12.9	1.0	0.2	1.0	n.d.

Atra. = atrazine; Brom. = bromacil; Sim. = simazine; Ter. Cl = terbuthylazine; Ter.D = terbumetone; Trif. = trifluralin.