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Hydrocoolers: Are They a Mechanism for Pesticide Transfer?

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In order to sell or distribute a pesticide in the United States, such pesticide must be registered with the Environmental Protection Agency (EPA) under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) (7 USC § 136a). Under FIFRA, the label and all accompanying labeling must conform to the terms agreed to in the registration process or else the product may be declared misbranded and removed from the market (7 USC § 136 q). The information on the label is designed to *protect health and environment* (7 USC § 136 q 1 G). It is a violation of FIFRA to utilize a pesticide in any way other than that proscribed by the product's registration and labeling (Thornton 1987).

In 1994, the Pesticide Control Program (PCP), a unit of the New Jersey Department of Environmental Protection (NJDEP), received information from the Food and Drug Administration (FDA) concerning a violative crop sample collected from their monitoring program. A crop sample is deemed violative if: a) the pesticide is labeled for use on the crop but the residue is above the EPA-established tolerance, or b) the pesticide is not labeled for use on the crop and therefore has no established tolerance. A tolerance is the maximum amount of a pesticide residue that is permitted in or on a food (Yess 1995). The crop sample in question was of green beans grown in New Jersey and the pesticide residue found on it was vinclozolin. Vinclozolin is not labeled for use on green beans. Investigation tracking back to the grower revealed no known application of the fungicide to the crop. It was learned during the investigation that the crop had been hydrocooled, a post harvest cooling process, raising the possibility that the water used in this process was the source of the residue. A pilot investigation was performed to determine if pesticides can be transferred from one crop to another via hydrocooler water.

Hydrocooling is one of several methods of precooling which are used to rapidly remove heat from certain freshly harvested fruits and vegetables (UT). Most researchers concur that the faster the temperature of produce is brought down to the storage temperature, the longer the shelf life of the produce will be (Wills 1989). The process of hydrocooling is unique, in that it utilizes water exclusively as the cooling medium. Produce is submerged in or

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showered with cold water, usually about 0°C, taking into account the chilling injury and freezing injury temperatures of the produce in question (Kays 1991). The water can actually clean the produce of dirt and pathogens (Phan 1987). However, it is a common practice for hydrocooler operators to re-use the water in the system. One can surmise that the water itself can become a reservoir for anything soluble on the crop or packaging. While some hydrocoolers may be dedicated to one crop, the expense of operation prompts growers with underutilized capacity to lease facilities to other growers. Grower cooperatives may purchase the hydrocooler to spread the expense (Flowers). In either case, there is a likelihood that several different crops will go through the same hydrocooler.

MATERIALS AND METHODS

An investigation was designed by PCP to cover the entire harvest season. In 1995, two hydrocoolers were secured for the study, both with a wide variety of crops being hydrocooled. Beginning in May 1995 and continuing through November 1995, water from the hydrocoolers was sampled weekly. Two samples were taken from each hydrocooler, one from the source water used to provide the hydrocooler with operating water and the other from the hydrocooler interior to characterize the water used in the process. The latter site is also referred to as the *dump tank* water in much hydrocooler literature. Sampling was done according to PCP protocol in 950ml clean amber jars, stored in a cool place until shipment to the laboratory for analysis. Analysis was done at Rutgers University. The analysis consisted of a multiresidue screen which is used for determination of pesticide residues in monitoring all of which was performed according to PCP protocol. A survey of all fifty state departments of agriculture and US Territories was undertaken to ascertain how widespread the practice of hydrocooling is and what crops are hydrocooled. A survey letter was mailed in May, 1995. In addition, pesticide food monitoring data was acquired from the State of California for 1993 and from FDA from the regulatory monitoring program 1992 to 1994. Unfortunately, neither database is a random sample of residues. The data may be biased by factors such as: commodity or place of origin, volume of production or historical data, all of which may be considered in selecting some samples (Yess 1995, CEPA 1993). A study was initiated by FDA to compare information gathered from the FDA regulatory monitoring approach and a random statistical sample to see if information from regulatory monitoring is representative of pesticide levels in the food supply. The study used a random sample of pears and tomatoes, comparing residues found in the random sample to those reported by regulatory monitoring. In general the study found agreement between the two forms of monitoring, but specific differences occurred due to variations in the number of pesticides screened as well as sampling differences. The study concluded that the regulatory monitoring approach is a valid measure of residues in food (Roy 1995).

RESULTS AND DISCUSSION

The survey to states was designed to collect information on actual, present-day hydrocooler use. Fifty percent of the surveys were returned. The results show that hydrocooling is performed in many locations on many crops. The results of the hydrocooler water sampling revealed that pesticides were present in 20 of 46 samples from the hydrocooler dump tanks. These samples constitute the water used in the process of hydrocooling which comes in contact with the produce. The four pesticides found were: metalaxyl, DCPA, iprodione, and vinclozolin. With the exception of DCPA, which is an herbicide, the remainder are fungicides. No pesticides were detected in the corresponding 46 source water samples.

Table 1. Pesticide Detections

Pesticide	Solubility	# of Detects	Range (μg/l)	$\bar{x}$ (μg/l)
Metalaxyl	7.1g/l	18	0.056 -1.842	0.651
DCPA	0.5mg/l	9	0.238 - 3.482	1.386
Iprodione	13mg/l	4	3.774 - 22.04	11.35
Vinclozolin	3.4mg/l	2	0.016 - 0.100	0.058

The levels of the pesticides found in the hydrocooler dump tank water ranged from 0.016 to 22.04 µg/l (Table 1). In order to gain a perspective on the levels, we compared the levels in the dump tank to levels used to apply the pesticide in the field. This was reasoned to be a valid comparison because the field application rates would expose the crops to the highest levels allowed by FDA. In order to determine application rates, we consulted product labels considered representative of the compounds at the PCP. Pesticides are generally labeled for use on more than one crop, often resulting in varying application rates. Therefore, we calculated a range of application rates for each pesticide from minimum and maximum application levels on each label which we could then compare to the levels found in our samples. For example, an application rate for iprodione (Rovral® WSP) for stone fruits is 1-2 pounds per acre. The suggested dilution maximum is 400 gallons per acre (Rhone-Poulenc Ag 1994). This would yield an application solution of 1 pound per 400 gallons and represent the lowest application rate found on the label. Conversely, the same label allows for an application rate on ginseng of 2 pounds per acre in a minimum dilution of 10 gallons per acre. This would yield an application solution of 2 pounds per 10 gallons and represent the highest application rate found on the label. By converting pounds per gallon to micrograms (µg) per liter (l) we can directly compare the application rates to the levels found in the hydrocooler water after accounting for the percentage active ingredient in the product. In the preceding example, the Rovral® WSP product used to estimate application rates of iprodione is actually 50% active ingredient. Multiplying the final result of the above conversion by 0.5 will yield “iprodione per liter”. This process was repeated for each pesticide. Actual calculations are as follows: The following conversions were utilized in the calculations:

$$\frac{1 kilogram}{2.2 pounds} \times \frac{1000 gm}{1 kg} \times \frac{1000 mg}{1 gm} \times \frac{1000 \mu g}{1 mg} = \frac{1 \times 10^{9} \mu g}{2.2 pounds}$$

$$\frac{1 gallon}{3785 ml} \times \frac{1000 ml}{1 \ell} = \frac{1000 gallon}{3785 \ell}$$

(Lowenthal 1980)

1. Iprodione (Rovral® WSP, Rhone-Poulenc Ag):

$$\frac{1 pound}{400 gallons} \times \frac{1000 gallon}{3785 \ell} \times \frac{1 \times 10^{9} \mu g}{2.2 pounds} \times 0.5 = \frac{1.5 \times 10^{5} \mu g}{\ell}$$

$$\frac{2 pounds}{10 gallons} \times \frac{1000 gallon}{3785 \ell} \times \frac{1 \times 10^{9} \mu g}{2.2 pounds} \times 0.5 = \frac{1.2 \times 10^{7} \mu g}{\ell}$$

The representative range for iprodione is 1.5 x 10^5 µg/l to 1.2 x 10^7 µg/l.

2. DCPA (Dacthal ® W-75 ISK):

$$\frac{20 pounds}{100 gallons} \times \frac{1000 gallon}{3785 \ell} \times \frac{1 \times 10^{9} \mu g}{2.2 pounds} \times 0.75 = \frac{1.8 \times 10^{7} \mu g}{\ell}$$

$$\frac{20 pounds}{40 gallons} \times \frac{1000 gallon}{3785 \ell} \times \frac{1 \times 10^{9} \mu g}{2.2 pounds} \times 0.75 = \frac{4.5 \times 10^{7} \mu g}{\ell}$$

The representative range for DCPA is 1.8 to 4.5 x 10^7 µg/l.

3. Vinclozolin (Ronilan® WP BASF):

$$\frac{2 pounds}{400 gallons} \times \frac{1000 gallon}{3785 \ell} \times \frac{1 \times 10^{9} \mu g}{2.2 pounds} \times 0.5 = \frac{3.0 \times 10^{5} \mu g}{\ell}$$

$$\frac{2 pounds}{20 gallons} \times \frac{1000 gallon}{3785 \ell} \frac{1 \times 10^{9} \mu g}{2.2 pounds} \times 0.5 = \frac{6.0 \times 10^{6} \mu g}{\ell}$$

The representative application rate for vinclozolin is 3.0 x 10^5 µg/l to 6.0 x 10^6 µg/l.

4. Metalaxyl (Apron® 50W CIBA):

$$\frac{0.03125 pounds}{0.078125 gallons} x \frac{1000 gallon}{3785 \ell} x \frac{1x10^9 \mu g}{2.2 pounds} x0.5 = 2.4x10^7 \mu g$$

$$\frac{0.4375 pounds}{0.078125 gallons} x \frac{1000 gallon}{3785 \ell} x \frac{1x10^9 \mu g}{2.2 pounds} x0.5 = \frac{3.36x10^8 \mu g}{\ell}$$

The representative application rates for metalaxyl are from 2.4 x 10^7 µg/l to 3.36 x 10^8 µg/l.

As can be seen in Table 2 below, the range of levels found in the dump tank water were orders of magnitude below that of the range of representative application rates found on product labels:

Table 2. Pesticide Detection Levels and Application Rates

Pesticide	Hydrocooler Water (µg/l)	Representative Application Rate (µg/l)
Metalaxyl	0.056 - 1.842	2.4 x 10^7 - 3.36 x 10^8
DCPA	0.238 - 3.482	1.8 - 4.5 x 10^7
Iprodione	3.774 - 22.04	1.5 x 10^5 - 1.2 x 10^7
Vinclozolin	0.016 - 0.100	3.0 x 10^5 - 6.0 x 10^6

This demonstrates that pesticide residue levels found in the hydrocooler dump tanks were lower than what would be found in an actual spray tank and that it is unlikely that the hydrocooler is applying pesticide in any significant level to a crop. While the presence of pesticide is apparent, the level does not indicate that the hydrocooler could deposit pesticide in significant amounts. The sample that initiated the hydrocooler project was a green bean sample which had a level of 0.094 ppm vinclozolin. The highest level of vinclozolin we found in the hydrocooler was 0.0001 ppm. While the study was not designed for comparison of the two levels, one can see that the hydrocooler vinclozolin level is three orders of magnitude lower than the level found on the beans. However, a level of 0.022ppm of iprodione, another fungicide, was also detected from the hydrocooler water. This result is on the same order of magnitude as the level found in the “real-world” crop sample.

Using the processing records of one hydrocooler, we were able to make an assessment on the possible sources of the pesticides in the hydrocooler dump tank. We compared daily records of crops hydrocooled and the pesticides labeled for use on them with the pesticide residues found in the hydrocooler water the same day. While the sample size does not allow definitive conclusions, it suggests that all pesticide residues found in the water could be accounted for by the crops which went through the hydrocooler on a particular day.

In an effort to see if any of the pesticide residues found in the hydrocooler water tend to be detected on the types of crops which went through the hydrocooler in the study, we consulted two food monitoring databases: the California database from 1993 and FDA monitoring database from 1992 to 1994. We performed extensive analysis of the databases to look for combinations of crops hydrocooled and pesticides found, similar to those found in this study.

The California data contains 9,329 samples. Analysis of the data revealed two, non-violative DCPA residues on lettuce (CEPA 1993). The 1992 FDA database contains 56,795 records (FDA 1992). When analyzed for the crops and pesticides found in this study, 164 matches were found. However, in no instance is a sample marked violative. The 1993 database contains 43,945 records (FDA 1993). Matches occurred in 40 samples, with none marked as violative. The 1994 database contains 40,539 records (FDA 1994). Matches occurred in 62 samples. Eight of these were termed violative: four samples of green beans from Belgium and four samples of chicory from Italy. All eight samples were found to have residues of vinclozolin, ranging from 0.08 to 0.440 PPM which is not labeled for use on either commodity.

The data from these two sources shows that while crops similar to those hydrocooled in this study were found with residues similar to those found in the hydrocooler dump tank water, only a very small percentage of sampled crops were found to be violative. Eight of the 268 record matches were violative for having residues of a pesticide not registered for use on the crop. As this type of violation was the impetus for the current study, it is important to note that the data do not indicate any major trends in this direction.

In summary, hydrocoolers are unlikely methods of pesticide transfer. This is supported by several findings in our preliminary study. The levels of pesticide residues found in hydrocooler water were low. When compared to representative application rates, the levels found in the hydrocoolers were several orders of magnitude less. Contrasting the residue levels in the hydrocooler with that found on the violative sample of green beans which initiated the study demonstrates that the hydrocooler water was several orders of magnitude less than the level on the beans. The crop records from the hydrocooler verify that the pesticide residues found in the water were registered for use on at least one crop hydrocooled that day. Finally, there does not seem to be any trend in the national food monitoring data to support that hydrocooling is responsible for pesticide movement between crops.

Our study is preliminary and limited. While the study has concluded that pesticide transfer is unlikely in hydrocoolers, it has also raised other issues. To our knowledge, there previously was no testing of hydrocooler water throughout a growing season. The finding of pesticide residues in hydrocooler water, while not unexpected, confirms the intuitive logic that they are present in varying levels and combinations directly related to the crops hydrocooled. While the levels found in this study were not high, their detection bolsters recommendations that hydrocooler water be changed daily (Boyette 1992). Certainly, more research in this area would be able to elucidate the effect of hydrocoolers on crop pesticide residues more definitively. Because the current study used a "real world" setting, many aspects were beyond our control. A study utilizing a hydrocooler quarantined for research would allow more questions to be answered. For example, spiking the dump tank water with a known quantity of pesticide and then using the unit to hydrocool residue-free produce could determine if deposition on crops occurs. Also, sampling "real-world" field crops before and after hydrocooling and sampling the dump tanks could help ascertain the fate and transport of pesticide residues.

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