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PESTICIDE RESIDUES ON NON-BELL PEPPERS IN PUERTO RICO

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ABSTRACT

The U.S. Environmental Protection Agency has established about 60 pesticide tolerances on peppers. However, only 5 pesticides have specific tolerances on bell peppers and 3 on Bohemian, Chili and Tabasco peppers. In Puerto Rico, common non-bell peppers such as Cubanelle, Blanco del País, Key Largo Hybrids, sweet cherry, and Jalapeño are grown commercially. More than fifteen field trials were conducted in Puerto Rico to develop efficacy, yield and residue data with several pesticides. The pesticides were either applied to the soil or to the foliage to obtain treated crop samples for pesticide residue determinations. Data on pesticide residue for fluazifop-butyl, fenamiphos, oxamyl, benomyl, acephate, and permethrin on non-bell pepper samples collected in Puerto Rico are discussed and compared to data on bell and non-bell peppers grown in continental USA. Regulatory status of fluazifop-butyl, fenamiphos, oxamyl, acephate, permethrin and benomyl on non-bell peppers are discussed. Potential pesticides for pest and disease control on non-bell peppers grown in the Caribbean Basin are identified.

INTRODUCTION

Cooking peppers (Cubanelle and Blanco del País cultivars) and sweet cherry peppers (known in Puerto Rico as ajíes dulces) are commercially grown in Puerto Rico. Blanco del País (*Capsicum annuum* L.), which has long and slender pods, is a cross between California Wonder and Cuaresmeño (Mexican hot pepper) (Riollano et al., 1948). In contrast, sweet cherry pepper (*Capsicum frutescens* L.) is a small and slightly flattened fruit. The marked variation in fruit size, shape and color does not permit the identification of varieties and lines of sweet cherry peppers. In 1987, upon request of US National Pepper Conference, Smith et al. made an horticultural classification of the most important forms of five pepper species grown in the United States.

For 1979-1987 mean production of cooking peppers was 9,920 short metric tons (SMT) with a farm value of $2.6 million. Mean production for sweet cherry peppers, however, was 757 SMT with a farm value of $217,115. In 1986-87, Puerto Rico production of sweet cherry peppers was 948 SMT with a farm value of $292,000 while imports from the Dominican Republic amounted to 1,990 SMT with a value of $376,016 (Private communication, 1988). Both the cooking peppers and the sweet cherry peppers are sold as fresh produce in several outlets or to local food processing plants for condiment. None of the peppers grown in Puerto Rico or imported as fresh produce are dehydrated and processed for powder condiment.

The United States Environmental Protection Agency (USEPA) has established about 60 pesticide tolerances on peppers. According to the 1987 Pesticide Chemical News Guide, there are five tolerances established specifically for bell peppers and three for non-bell pepper types such as Chili, Tabasco, and Jalapeño. The USEPA has considered that tolerances established for peppers include all varieties of peppers including pimentos and bell, hot and sweet peppers (49 CFR 180.1 (h), USEPA, 1985).

The federal agency, however, has questioned the expansion of pesticide tolerances as approved for bell peppers to non-bell peppers such as Cubanelle, Blanco del País, and sweet cherry peppers grown in Puerto Rico. Cultivation and management practices, industrial processing, wax content, days from transplanting to harvesting, days after last pesticide treatment, fruit shape and size, and weight/volume ratio must be considered before established bell pepper tolerances are extended to all non-bell peppers grown in Puerto Rico.

A search through USDA Current Research Information System (CRIS) data base and other resources has shown a scarcity of publications dealing with pesticide residue determinations on non-bell peppers collected from field trials. Al-Samarie et al. reported residue levels on three organophosphorus insecticides in sweet peppers grown in commercial greenhouses (Al-Samarie et al., 1988).

Interregional Research Project (known as IR-4) "National Agriculture Program to Clear Pest Control Agents and Animal Drugs for Minor Uses" is a joint effort between the USDA-Agricultural Research Service (ARS) and USDA-Cooperative State Research Service (CSRS), the United States Environmental Protection Agency, the Food and Drug Administration (FDA), the State Agricultural Experiment Stations (SAES), individual researchers, animal drug and pesticide manufacturers and growers. With the assistance of the IR-4, field trials were conducted in Puerto Rico to develop performance (efficacy and effect on yield and quality) and residues data for several pesticides for control of pests and diseases on non-bell peppers such as Cubanelle, Blanco del País and sweet cherry peppers.

This paper reports results and findings on pesticide residues for non-bell pepper samples from Puerto Rico and other locations in continental United States.

MATERIALS AND METHODS

Pesticide needs for non-bell peppers were identified by the Puerto Rico IR-4 Liaison Representative with the assistance of researchers, specialists, and extension agents of the College of Agricultural Sciences of the University of Puerto Rico-Mayaguez Campus; growers, members of state agricultural agencies and growers' associations; and representatives of pesticide manufacturers. High priority needs, as identified by the Puerto Rico

Agricultural Experiment Station, were submitted as IR-4 pesticide clearance requests (PCR) through the regional office (University of Florida, Gainesville, Florida) to IR-4 National Headquarters at the Rutgers University, New Brunswick, New Jersey. Information to be requested and gathered for a PCR has been previously reported (Montalvo-Zapata et al., 1987; Meister, 1984).

After careful screening, both at the Regional Office and National Headquarters, each PCR was examined to meet specific criteria as requested by IR-4. With the help of the requester and industry, a research test protocol was developed by IR-4 to generate efficacy, effect on yield and quality of commodity, and residue data.

Each field trial was established following IR-4 guidelines for experimental design, plot size, treatments, rates, frequency, method of application, harvesting and field sampling. Residue samples were collected from one and two times the proposed used rate and the control or as prescribed for the specific pesticide. They were transferred immediately to the Pesticide Laboratory in Río Piedras, frozen at -20ºC in a walk-in freezer, and later packed in appropriate bags and shipped in containers with dry ice to either the IR-4 Regional Laboratory or pesticide manufacturer laboratory in the United States.

Most of the determinations were performed following residue analysis procedures for oxamyl as developed by Thean et al., 1978, for permethrin (Fujie et al., 1978), and fluazifop-butyl as developed by ICI Americas, for acephate and metamidophos as developed by Chevron Chemical Co., 1973, and for fenamiphos as developed by Thornton, 1971. Benomyl residue determinations were done by Analytical Development Corporation at Colorado Springs, Colorado, following a modified procedure of Kirkland et al., 1986. Some of the crop samples were analyzed either by the pesticide manufacturers, IR-4 Regional Laboratories (University of Florida, Gainesville, Florida, and Cornell University, Ithaca, New York) or USDA-ARS Laboratories at Savannah, Georgia, and Stoneville, Mississippi.

All field and laboratory data were compiled and evaluated by the IR-4 Regional and Headquarters offices and the pesticide manufacturers. In addition, residue data on bell peppers and other types of non-bell peppers grown through US were either supplied to IR-4 Headquarters or to the senior author and compared with information developed from Puerto Rico trials.

RESULTS AND DISCUSSION

A. Pesticide Residue Data

1. Herbicide

a. <u>Fluazifop-butyl</u>

Fluazifop-butyl maximum residues on Cubanelle peppers resulting from a single postemergence application at the rates of 0.28 and 0.56 kg a.i. ha^{-1} were less than 0.1 ppm at 83 days after treatment (Table 1). These residues are much lower when compared to maximum residues detected on either Chili, Tabasco and Jalapeño peppers treated with two applications of Fusilade 2000 at the rate of 0.42 kg a.i. ha^{-1} and collected 45 days after the last spray.

2. Nematicides

a. Fenamiphos

Maximum fenamiphos residues, resulting from banded applications of Nemacur 15G on Cubanelle peppers were 0.018 and 0.043 ppm when applied at the rate of 2.24 and 4.48 kg a.i. ha^{-1}, respectively (Table 2). Fenamiphos residues on sweet cherry peppers treated at the rate of 1.12 and 2.24 kg a.i. ha^{-1} were below detectable limits when harvested 111 days after treatment.

Table 2 also shows fenamiphos residues of 0.073 ppm on Chili peppers when a broadcast application was made at the rate of 6.72 kg a.i. ha^{-1}. But maximum fenamiphos residues of 0.459 ppm were detected on Hungarian Hot peppers treated at the rate of 6.72 kg a.i. ha^{-1} and harvested at 38 days after soil treatment.

Relationships between fenamiphos residue levels on bell peppers resulting from a broadcast application of the Nemacur 15G formulation at two rates were not linear even when the application rate was doubled. However, fenamiphos residue levels on bell pepper samples from Texas, Utah, and Georgia are quite similar to levels found on Chili peppers at the same application rate.

b. Oxamyl

Residues ranging from 0.29 to 0.59 ppm were found on Cubanelle peppers, 7 days after last treatment, from plots treated with seven Vydate L foliar applications of 0.56 to 1.12 kg a.i. ha^{-1}, respectively (Table 3). The oxamyl residues on sweet cherry peppers receiving a transplant water treatment followed by 9 foliar applications of Vydate L at 1.12 kg a.i. ha^{-1} were 0.75 ppm. Oxamyl residues were 0.59 ppm on sweet cherry peppers when only 9 foliar applications of Vydate L were made.

Table 3 also shows low oxamyl residue levels (0.16 ppm) on Jalapeño peppers in Florida resulting from a transplant water treatment (TPW) at the rate of 0.56 kg a.i. ha^{-1}. The combination of TPW with seven foliar sprays of Vydate L resulted in much higher oxamyl residue levels (3.3 ppm). Data also indicates that oxamyl residue levels decrease as days between last application and harvest increase.

3. Insecticides

a. Permethrin

Table 4 shows permethrin residue data on Cubanelle and Jalapeño peppers. Data indicates that eight foliar applications of Ambush 2.5W insecticide resulted in combined residues (cis and trans isomers) of 0.36 and 0.84 ppm when used at the rates of 0.11 and 0.22 kg a.i. ha^{-1}, respectively. Higher permethrin levels were detected on Jalapeño peppers from Florida when the insecticide rates were doubled. Permethrin residue levels, regardless of pepper type, were proportional to the rate applied to the foliage.

b. Acephate

Samples of Cubanelle and Blanco del Pafs peppers were collected in Puerto Rico and analyzed for residue determinations of acephate and its metabolite metamidophos (Table 5). Acephate residue levels were about 3.0 ppm regardless of non-bell pepper cultivars when treated with six sprays of Orthene 75S at the rate of 1.12 kg a.i. ha^{-1}. However, acephate residue levels ranged from 1.45 to 2.18 ppm when four sprays of 1.12 kg a.i. ha^{-1} of Orthene 75S were followed by two applications at 0.56 kg a.i. ha^{-1} rate. Metamidophos residue levels were less than 1 ppm on both sets of non-bell peppers, thus complying with USEPA requirement that no more than 1.0 ppm can be metamidophos metabolite.

Acephate and metamidophos residue levels, however, were lower when Jalapeño peppers were treated with seven foliar sprays of Orthene 75S.

4. Fungicides

a. Benomyl

Benomyl residue data on Cubanelle peppers are shown on Table 6. Unfortunately, the 1985 samples set was lost at a fire in Du Pont's warehouse facility at Wilmington,Delaware. Residue levels of benomyl on a 1986 pepper trial (Cubanelle cv), ranged from 0.14 to 0.66 ppm when treated with seven foliar sprays of Benlate WPat D.28 and 0.56 kg a.i. ha^{-1}, respectively.

None of benomyl metabolites 2-aminobenzimidazole (2-AB) and 2-benzimidazole carbamate (MBC) residue levels were determined on the pepper samples analyzed.

b. Triadimefon

Two sets of samples of Cubanelle peppers were collected and shipped for triadimefon residue determination. However, problems encountered during analysis of main active ingredient and its three metabolites impeded the residue analysis.

B. Regulatory Status

1. Herbicides

IR-4 has submitted tolerance petitions for fluazifop-butyl on Chili pepper (California only), Tabasco pepper (Louisiana only), Jalapeño pepper (Georgia only) and Cubanelle pepper (Puerto Rico only). USEPA has only established a fluazifop-butyl tolerance of 1.D ppm on Tabasco pepper grown in Louisiana.

Further work is being completed to supply USEPA with data to establish an unrestricted pepper tolerance.

2. Nematicides

IR-4 has submitted a tolerance petition for the use of a single application of fenamiphos on non-bell peppers. This tolerance petition is still under USEPA review.

USEPA established a 3 ppm tolerance for oxamyl on bell peppers. Based on residue data from Puerto Rico, California, Florida, Texas, and Arizona, IR-4 submitted an unrestricted tolerance petition (5 ppm) for oxamyl on non-bell peppers. USEPA found this proposed tolerance unacceptable. IR-4 has modified the petition and requested a 3 ppm tolerance for oxamyl on Cubanelle and sweet cherry peppers for Puerto Rico only.

3. Insecticides

USEPA has established a 1 ppm tolerance for permethrin on bell peppers. This agency, however, has requested additional residue data on permethrin and its three metabolites (m-phenoxy benzyl alcohol, cis-dichlorovinyl and trans-dichlorovinyl) in order to approve a tolerance on non-bell peppers.

Based on residue data for bell and non-bell peppers as submitted by the pesticide manufacturer, USEPA has established an unrestricted tolerance (4 ppm) for combined residues of acephate and its O,S-dimethyl phosphoramidate metabolite on peppers.

4. Fungicides

USEPA established a 0.2 ppm tolerance of benomyl and its metabolites containing the benzimidazole moiety when used as a drench soil treatment on peppers. IR-4 has developed residue data for benomyl as a foliar spray on various non-bell peppers and has requested a 5 ppm tolerance.

C. General Considerations

Growth characteristics for bell and several varieties of non-bell peppers are shown on Table 7.

Data on Table 7 reveal that the weight to volume surface ratio is 0.31 on bell peppers as compared to values ranging from 0.39 to 0.69 on several non-bell peppers with the exception of 0.92 on hot peppers grown in Puerto Rico. Efforts should also be directed to have reliable weight/volume surface ratio for the most common types of peppers cultivated in continental US, Virgin Islands, Puerto Rico, Hawaii, and Guam. Possibly, pesticide residues expected on Cubanelle, Blanco del País, Key Largo Hybrids and sweet cherry peppers grown in Puerto Rico could be similar in magnitude as those recorded for bell peppers.

More field research must be conducted to determine the residue levels of selected systemic pesticides on simultaneous plantings of the most common types of peppers grown commercially in each state or region. Parameters such as formulation, use pattern, and days after last treatment must be the same for all sites. Other factors such as location, year, season, rainfall, temperature, sunlight, post harvest interval (PHI), cultivation practices and others are important variables to be considered in the assessment of pesticide residues on bell peppers as compared to non-bell peppers.

After analysis of all data from different states and regions, it will be possible to predict residue levels of potential systemic pesticides for pest and disease control on major types of peppers grown in US and its territories. Further research should also be conducted to determine the wax content for each major pepper type and the correlation between wax content and pesticide residue levels.

IR-4 is developing performance data (efficacy, effect on yield and quality, as well as residues) for fungicides such as iprodione, carboxin and chlorothalonil and herbicides such as bentazon, diquat and pendimentalin. These pesticides are needed for pest and disease control on non-bell peppers grown in Puerto Rico and USA. Pesticide residue data developed in Puerto Rico could be useful for those Caribbean Basin countries interested in pepper exports to the US.

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Table 1.--Fluazifop-butyl residues on peppers resulting from applications of Fusilade 2000 herbicide.

Pesticide	Location/year/ pepper type	Treatments kg a.i. ha^{-1}	Type of application	Number of applications	Days after last treatment	Maximum residues detected (ppm)1/
Fluazifop-butyl	CA/1986/Chili	0.42	Postemergence	2	45	0.5
	LA/1984/Tabasco	0.42	"	2	45	0.84
	CA/1986/Jalapeño	0.42	"	2	45	0.23
	MD/1985/Bell	0.42	"	2	46	0.1
	GA/1986/Bell	0.42	"	2	45	0.36
	PR/1986/Cubanelle	0.28	"	1	83	<0.1
		0.56	"	1	83	<0.1

1/ Residue analysis includes fluazifop-butyl and its conjugates.

Table 2.--Fenamiphos residues on non-bell and bell peppers resulting from applications of Nemacur 15G.

Location/year/pepper type	Treatments kg a.i. ha^{-1}	Days after last treatment	Maximum Fenamiphos residues (ppm) b/
PR/1985/Cubanelle	2.24 a/, banded	70	0.018
	4.48 , banded	70	0.043
PR/1986/Sweet cherry	1.12 , banded	111	N.D.R.
	2.24 , banded	111	N.D.R.
CA/1982/"Hungarian Hot"	3.36, broadcast	38	0.095
	6.72 "	38	0.459
CA/1986/Chili	6.72 "	76	0.073
UT/1984/Bell	3.36 "	63	0.040
	6.72 "	63	0.030
	13.44 "	63	0.040
GA/1982/Bell	3.36 "	52	0.037
	6.72 "	52	0.054
FL/1987/Bell	6.72 "	74	0.178
	13.44 "	74	0.420
TX/1987/Bell	6.72 "	76	0.035
	13.44 "	76	0.089

a/ Actual material applied per hectare, the rates of 2.24 and 4.48 kg a.i. ha^{-1} banded are equivalent to broadcast rates of 6.72 and 13.44 kg a.i. ha^{-1} on 14.17 cm row spacings. Band width was 4.72 cm.

b/ Included fenamiphos and its cholinesterase inhibiting metabolites.

Table 3.--Oxamyl residues on non-bell peppers resulting from applications of Vydate L.

Location/year/pepper type	Treatments kg a.i. ha^{-1}	Number of foliar applications	Days after last treatment	Mean oxamyl residues g/ (ppm)
PR/1985/Cubanelle	0.56 (Foliar) a/	7	7	0.29
	1.12 (Foliar) a/	7	7	0.59
PR/1986/Sweet cherry	0.56 (TPW) + 1.12 (Foliar) b/	9	7	0.75
	1.12 (Foliar b/	9	7	0.59
CA/1985/Jalapeño	0.56 (TPW) + 1.12 (Foliar) c/	12	7	0.74
FL/1986/Jalapeño	0.56 (TPW) d/	0	63	0.16
	0.56 (TPW) + 1.12 (Foliar) e/	7	7	3.33
TX/1987/Jalapeño	0.56 (TPW) + 1.12 (Foliar) f/	7	14	0.29

a/ Foliar applications were made on 6/10, 6/17, 6/25, 7/2, 7/10, 7/16, and 7/23.
b/ Transplant Water Treatment (TPW) made on 4/24 and foliar applications were made on 5/7, 5/15, 5/29, 6/12, 6/26, 7/14, 7/22, 7/29, and 8/5.
c/ TPW made on 4/25/85, followed by foliar applications on 5/10, 5/17, 5/24, 5/31, 6/7, 6/14, 6/21, 6/28, 7/5, 7/12, 7/19, and 7/26.
d/ TPW made on 8/29/86.
e/ TPW made on 8/29/86, followed by foliar applications on 9/12, 9/19, 9/26, 10/3, 10/10, 10/17, and 10/24.
f/ Drench Treatment made on 3/31/87, followed by foliar applications on 4/7, 4/14, 4/21, 4/28, 5/5, 5/13, and 5/27.
g/ Each figure represents the means of 4 replicates.

Table 4.--Permethrin residues resulting from foliar applications of Ambush 25W.

Location/year/pepper type	Treatment kg a.i. ha^{-1}	Number of applications	Days after treatment	Permethrin residues (ppm) 3/
PR/1985/Cubanelle	0	0	3	0
	0.11	8 1/	3	0.36 4/
	0.22	8 1/	3	0.64 4/
FL/1985/Jalapeno	0	0	3	0.1
	0.22	8 2/	3	0.5 4/
	0.44	8 2/	3	1.7 4/

1/ Foliar applications were made on 6/10, 6/17, 6/25, 7/2, 7/10, 7/16, 7/23, and 7/29.
2/ Foliar applications were made on 9/12, 9/19, 9/26, 10/3, 10/10, 10/17, 10/24, and 10/31.
3/ Means of 4 replications per treatment.
4/ Each figure represents the total of cis and trans isomers.

Table 5.--Acephate and metamidophos residues on non-bell peppers resulting from foliar applications of Orthene 75S.

Location/year/pepper type	Treatment kg a.i. ha^{-1}	Number of appli-cations	Days after last treatment	Residues (ppm)	
				Ace-phate	Metami-dophos
PR/1981/Cubanelle	1.12	6 1/	7	3.15	0.90
	1.12 + 0.56	6 2/	7	1.45	0.46
PR/1981/Blanco del País	1.12	6 3/	7	3.05	0.77
	1.12 + 0.56	6 4/	7	2.18	0.61
MI/1977/Jalapeño	0.56	7 5/	6	0.50	0.23
	1.12 + 0.56	7 5/	6	0.83	0.44

1/ Foliar applications performed on 5/6, 5/13, 5/20, 5/27, and 6/3 and 6/10.
2/ Foliar applications at 1.12 kg a.i. ha^{-1} were on 5/6, 5/13, 5/20, 5/27, followed by 0.56 kg a.i. ha^{-1} on 6/3 and 6/10.
3/ Foliar applications performed on 5/28, 6/4, 6/6, 6/11, 6/18, and 7/2.
4/ Foliar applications at 1.12 kg a.i. ha^{-1} were on 5/28, 6/4, 6/6, 6/11, 6/18, followed by 0.56 kg a.i. ha^{-1} on 6/25 and 7/2.
5/ Foliar applications at 1.12 kg a.i. ha^{-1} were on 6/28, 7/12, 7/26, 8/3, 8/12, 8/19 and 8/26.

Table 6.--Benomyl residues on Cubanelle peppers resulting from foliar applications of Benlate Fungicide Wettable Powder.

Location/year/pepper type	Treatment kg a.i. ha-1	Number of applications	Days after last application	Benomyl residues (ppm)
PR/1985/Blanco del País				
	0	-	-	2/
	0.28	7	7	2/
	0.56	7	7	2/
PR/1986/Cubanelle	0	-	-	0.05
	0.28	7 1/	7	0.14
	0.56	7	7	0.66

1/ Foliar applications were performed on April 2, 7, 9, 17, 23 and 30, and May 7.
2/ Samples lost at a fire at Du Pont's warehouse facility at Wilmington, Delaware.

Table 7.--Weight, volume, length, width, and weight/volume surface ratio for bell and non-bell peppers.

Type of pepper	Weight/fruit (g)	Volume/fruit (ml) 1/	Fruit size (cm)		Weight/volume surface ratio
			Length	Width	
Bell	149.8	487.1	12.1	8.1	0.31
Non-bell					
Cubanelle	51.2	103.1	12.1	4.4	0.49
Key Largo Hybrid	79.8	149.5	13.8	4.4	0.53
Jalapeño	13.6	19.7	6.2	2.6	0.69
Hungarian Yellow Wax	27.8	51.7	12.3	3.4	0.54
Sweet cherry	2.8	7.2	1.9	1.8	0.39
Hot	1.2	1.3	3.6	1.4	0.92

1/ Volume of water displaced by peppers in a graduated cylinder.

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