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Pesticide Use Changes in New York Vegetables: 1978 to 1998

Abstract
Pesticide use patterns in 1978 and 1998 were compared for 15 vegetable crops grown in New York State. Insecticide use decreased in almost all vegetables over this period, with an overall decline of 65%. Total herbicide use declined 24%, while fungicide use increased 76%. Within crops, potatoes and onions received more than 60% of all pesticide use on vegetables. Large declines in pesticide use occurred in some crops and usually were associated with the substitution of low use-rate for high use-rate insecticides or herbicides. Strategies for future reductions in pesticide use are discussed.

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Introduction

Reducing the use of pesticides in agriculture is a public policy objective increasingly adopted at many levels of society. Integrated pest management concepts and techniques designed in part to reduce pesticide use are common components of agricultural Extension programs. However, thorough assessments of pesticide use trends that can be used to measure impacts or as a guide to help steer future efforts are often lacking.

Analysis of pesticide use trends can provide critical information on the impacts of regulatory, research, extension and farm policies that either directly or indirectly affect the pest management choices that farmers make (Gianessi & Silvers, 2000). Our study compared pesticide use on vegetable crops in New York over a 2-decade span, from 1978 to 1998, and also identified potential factors that might explain shifts in use patterns and possible strategies for future pesticide reductions.

Materials and Methods

Pesticide use patterns in 1978 and 1998 were compared for 15 major New York vegetable crops. Data were calculated for amount of insecticide, fungicide, and herbicide active ingredient applied on a statewide and a per hectare basis. Raw data were drawn primarily from two sources, Muka and Heath (1979) and Stivers (1999). In 1978, Muka and Heath conducted an in-depth statewide survey of pesticide use patterns of vegetable producers in New York as part of a USDA Pesticide Impact Assessment Program project. In 1999, Stivers developed "crop profiles" for the major

vegetable crops produced in New York through a USDA-funded project. Information for 1997 and 1998 on pesticide use was collected from processor records, grower surveys, and interviews with private consultants. Unlike data collected by the USDA National Agricultural Statistics Service (Anonymous 1997), information in the Muka and Heath (1979) and Stivers (1999) reports reflects all pesticide use in vegetables in the state.

Results & Discussion

Production Statistics

Total vegetable production (metric tons harvested) in New York declined only slightly (3%) from 1978 to 1998, while the number of hectares devoted to vegetable production declined 13% (Table 1). In general, statewide production levels were maintained through increased crop yields.

Total Pesticide Use

Slightly (8%) less total pesticides (MT of active ingredients) were applied to vegetable crops in New York in 1978 compared with 1998 (Table 1). Potatoes and onions combined accounted for more than 60% of all pesticides used in vegetables in 1978 and 1998, thus these two crops had a substantial impact on overall use trends in the state. The amount of pesticides applied per hectare varied considerably by crop, but calculated as an average over all crops, increased approximately 18% from1978 to 1998 (Table 1).

Table 1.
Production and Total Pesticide Use on Vegetables in New York: 1978 and 1998

	Harvested Hectares (× 1,000)		**Total Production (1,000 MT)**		**Total Applied (MT ai)**		**Per Hectare of Crop (kg ai)**	
Vegetable Crop	**1978**	**1998**	**1978**	**1998**	**1978**	**1998**	**1978**	**1998**
Beets	2.0	0.9	65.3	25.0	8.4	6.2	3.9	5.7
Cabbage	6.3	6.7	239.0	277.0	50.1	66.2	7.7	9.6
Carrots	0.8	0.7	26.3	31.8	13.4	6.4	16.5	9.2
Cucumbers	1.0	1.5	11.9	34.5	6.6	9.1	6.0	5.9
Dry Beans	17.0	12.15	19.4	19.3	89.5	76.5	4.8	6.1
Lettuce	1.4	0.2	30.2	7.5	15.2	3.1	9.1	10.9
Onions	5.6	5.1	189.2	170.1	258.0	185.7	43.9	35.0
Peas	2.3	7.4	7.3	34.9	3.5	8.2	1.5	1.1
Peppers	0.4	0.4	NA	NA	1.2	5.2	3.4	12.0
Potatoes	19.6	10.9	574.0	330.7	508.5	481.9	25.3	43.1
Pumpkins	NA	2.2	NA	73.3	NA	19.4	NA	8.8
Snap Beans	23.0	8.4	109.6	69.8	112.6	53.1	4.8	6.2

Squash	0.9	1.2	NA	NA	4.1	7.2	4.7	6.1
Sweet Corn	17.1	27.7	154.3	318.4	93.6	137.9	5.2	4.7
Tomatoes	2.4	1.3	29.4	21.0	22.9	27.7	9.1	20.1
Total or avg.	99.7	86.9	1,455.8	1,413.3	1,187.7	1,093.7	10.4	12.3

Insecticide Use

From 1978 to 1998, insecticide use decreased in almost all vegetables when measured on a statewide basis and a per hectare basis (Table 2). A total of 383,446 kg of insecticides (active ingredient) were used in 1978, compared with 135,810 kg in 1998, a decline of 65%. In several crops, including potatoes, dry beans, carrots, onions, tomatoes, and sweet corn, declines in insecticide use were dramatic.

Table 2.
Insecticide Use on Vegetables in New York: 1978 and 1998*

	Total Applied (kg ai)		**Per Hectare of Crop (kg ai)**		
Vegetable Crop	**1978**	**1998**	**1978**	**1998**	**Percentage Change**
Beets	0	0	0	0	-
Cabbage	41,533	29,117	6.3	4.3	-31.7
Carrots	**6,408**	**427**	**7.9**	**0.6**	**-92.4**
Cucumbers	1,327	1,020	1.2	0.7	-41.7
Dry Beans	18,673	6,158	1	0.5	-50.0
Lettuce	**7,836**	**448**	**4.7**	**1.6**	**-66.0**
Onions	**31,994**	**8,097**	**5.4**	**1.5**	**-72.2**
Peas	39	0	0	0	-
Peppers	925	1,344	2.6	3.1	+19.2
Potatoes	**201,446**	**53,421**	**10**	**4.8**	**-52.0**
Pumpkins	NA	2,512	NA	1.1	NA
Snap Beans	13,802	4,604	0.6	0.5	-16.7
Squash	2,276	2,860	2.6	2.4	-7.7

Sweet Corn	**52,467**	**25,101**	**2.9**	**0.9**	**-69.0**
Tomatoes	**4,720**	**701**	**1.9**	**0.5**	**-73.7**
Total or avg.	383,446	135,810	3.4	1.5	-46.1
* Shaded rows with strong text indicate crops with substantial (>50%) reductions in insecticide use per hectare.					

Most of the insecticide use decreases in vegetables can be attributed to the replacement of organophosphate and carbamate products with lower-use rate insecticides such as pyrethroids and neonicotinoids. For example, in potatoes, growers switched from multiple applications of organophosphates and carbamates to one application of the neonicotinoid insecticide, imidacloprid, for control of Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Boiteau, Osborn, & Drew, 1997). In onions, growers switched from organophosphates applied at ~ 1.0 kg ai/ha to pyrethroids applied at <0.1 kg ai/ha for control of onion thrips, *Thrips tabaci* Lindeman (Reiners, Petzoldt, & Hoffman, 2000).

Adoption of integrated pest management (IPM) programs also contributed to declines in insecticide use. In sweet corn, monitoring for European corn borer, *Ostrinia nubilalis* Hübner (Shelton, 1986), contributed to a 79% decline in insecticide use per hectare. In onions, successful IPM of thrips and onion maggot *Delia antiqua* (Meigen) (Hoffmann, Petzoldt, & Frodsham, 1996) helped to reduce the frequency of insecticide applications from 3.0 per season in 1978 to 1.8 per season in 1998.

Fungicide Use

Fungicide use varied among vegetable crops in New York, but the general trend was for increased fungicide use (Table 3). Fungicide use statewide increased 76% from 1978 to 1998. Only one crop, cucumbers, showed a decline (albeit minimal) in fungicide use on a per hectare basis. In 1998, potatoes ranked number one in fungicide use per hectare and accounted for 58% of total fungicide use in vegetables. Onions were a close second in fungicides used per hectare, accounting for 24% of the total on all vegetables.

Table 3.
Fungicide Use on Vegetables in New York: 1978 and 1998

	Total Applied (kg ai)		**Per Hectare of Crop (kg ai)**		
Vegetable Crop	**1978**	**1998**	**1978**	**1998**	**Percentage Change**
Beets	0	66	0	0.1	-
Cabbage	5,903	28,168	0.9	4	+344.4
Carrots	5,094	5,128	6.3	7.4	+17.5
Cucumbers	4,173	5,552	3.8	3.6	-5.3
Dry Beans	891	1,457	0	0.1	-
Lettuce	4,027	2,460	2.4	8.7	+262.5
Onions	79,240	145,432	13.5	27.4	+103.0
Peas	12	686	0	0.1	-

Peppers	143	3,183	0.4	7.4	+1750.0
Potatoes	225,503	353,699	11.2	31.6	+182.1
Pumpkins	NA	14,268	NA	6.5	NA
Snap Beans	7,021	8,966	0.3	1.1	+266.7
Squash	261	4,006	0.3	3.4	+1033.3
Sweet Corn	370	15,336	0	0.5	-
Tomatoes	16,640	25,463	6.6	18.5	+180.3
Total or avg.	349,278	613,870	3.3	8.0	+413.5

The major reason for the increase in fungicide use in potatoes (and tomatoes) was the relatively recent immigration of a metalaxyl-resistant strain of *Phytophthora infestans*, the pathogen causing late blight disease (Fry and Goodwin, 1997). Since the occurrence of metalaxyl-resistant *P. infestans*, producers have had to rely on frequent applications of protectant fungicides on their entire crop. Sixty-seven percent of all fungicides used on potatoes in 1998 were foliar applications for control of late blight and early blight, including mancozeb, maneb, metiram, and chlorothalonil, which were also the predominant foliar fungicides used in 1978. Fungicide use in onions and cabbage also increased considerably from 1978 to 1998.

Herbicide Use

Total herbicide use on vegetables declined 24% from 1978 to 1998 (Table 4). Herbicide use in onions was the highest of all vegetables in 1978 on both a statewide and a per hectare basis, but decreased dramatically (78% statewide and 76% per hectare) by 1998. In 1978, onion growers typically applied CDAA (Randox) at a rate of 5.9 kg ai/ha, two to three times per season, accounting for much of the herbicide use. In 1998, producers used a variety of post-emergence herbicides at rates ranging from 1.7 kg/ha (pendimethalin and metolachlor) to 0.0022 kg/ha (oxyfluorfen) with an application frequency of one to three times per season. In addition, use of sprout inhibitors (chloropropham and maleic hydrazide) fell from 42,000 kg in 1978 to 7,100 kg in 1998. Thus, the dramatic decline in onion herbicide use is largely explained by the shift away from two high use-rate herbicides to multiple herbicides of relatively low use rates.

In other vegetables, such as potatoes, high use-rate herbicides (EPTC at 4.7 kg ai/ha and linuron at 1.4 kg ai/ha) have largely been replaced by lower use-rate materials (metribuzin at 0.67 kg ai/ha). However, these reductions have been more than offset by an increase in the use of sprout inhibitors and vine-killing herbicides such as paraquat and diquat.

Table 4.
Herbicide Use on Vegetables in New York: 1978 and 1998*

	Total Applied (kg ai)		**Per Hectare of Crop (kg ai)**		
Vegetable Crop	**1978**	**1998**	**1978**	**1998**	**Percentage Change**
Beets	8,446	6,123	3.9	5.6	+43.6
Cabbage	2,664	8,926	0.5	1.3	+160.0
Carrots	1,858	810	2.3	1.2	-47.8

Cucumbers	1,054	2,522	1	1.6	+60.0
Dry Beans	69,973	68,873	3.8	5.5	+44.7
Lettuce	**3,313**	**167**	**2**	**0.6**	**-70.0**
Onions	**146,754**	**32,149**	**25**	**6.1**	**-75.6**
Peas	3,494	7,534	1.5	1	-33.3
Peppers	144	623	0.4	1.5	+275.0
Potatoes	81,588	74,816	4.1	6.7	+63.4
Pumpkins	NA	2,606	NA	1.2	NA
Snap Beans	91,728	39,519	3.9	4.6	+17.9
Squash	**1,555**	**362**	**1.8**	**0.3**	**-83.3**
Sweet Corn	40,811	97,417	2.3	3.3	+43.5
Tomatoes	1,555	1,534	0.6	1.1	+83.3
Total or avg.	454,937	343,981	3.8	2.8	-26.9
* Shaded rows with strong text indicate crops with substantial (>50%) reductions in herbicide use per hectare.					

Implications for Extension: Strategies for Future Pesticide Use Reductions

In New York vegetable production, factors such as market demands for increased quality, stagnant commodity prices, development of pesticide resistance in certain pests, and rising costs of labor have tended to increase the use of pesticides, especially fungicides and herbicides. In contrast, factors such as the introduction of new pesticides with lower use-rates, availability of varieties with improved pest tolerance, rising costs of pesticides, increased regulations, and the adoption of IPM practices have tended to lower the use of pesticides, particularly insecticides.

If a further reduction in pesticide use without a significant decline in vegetable production is the goal, three targeted strategies would have more impact than broader efforts aimed across all vegetable commodities. Successful implementation of these strategies would involve the pesticide manufacturing, regulatory, agricultural research and extension arenas.

1. Reducing the Use of Protectant Fungicides in Potatoes and Onions

The EBDC fungicides (mancozeb, maneb, and metiram) plus chlorothalonil represented over 40% of all pesticide use in vegetables in 1998 (Table 5). Most of this fungicide use occurred in potatoes and onions. New Qo1 inhibitors (strobilurans) such as azoxystrobin (Quadris) hold some potential for at least partially substituting for protectant fungicides (Leroux, 1996; Gullino, Leroux, & Smith, 2000), but other alternatives are needed. The availability of new fungicides with curative efficacy for late blight would significantly reduce the use of protectant fungicides in potatoes.

The use of weather-based disease forecasting systems for late blight in potatoes and Botrytis leaf blight in onions could also reduce fungicide applications in New York (Fohner, Fry, & White, 1984; Vincelli & Lorbeer, 1989). Use of the BLIGHT-ALERT forecasting scheme has been shown to reduce fungicide use in onions by up to 44% (Hoffmann et al., 1996).

2. Reducing the Use of High-Rate Herbicides, Especially in Beans and Sweet

Corn

The high-use-rate herbicides, Metolachlor (Dual) and EPTC (Eptam), accounted for 41% of herbicide use and 13% of all pesticide use in vegetables in 1998. Ninety-two percent of the EPTC use and 24% of the metolachlor use occurred in snap and dry beans (Table 5). Weed control programs in beans that move away from these active ingredients, either by a greater reliance on post-emergence herbicides such as fomesafen or on mechanical weed control, could significantly reduce herbicide use. Forty-eight percent of the metolachlor use and 100% of the atrazine use in 1998 occurred in sweet corn. Despite regulatory pressures on both of these herbicides, alternative herbicides, which could serve as complete substitutes have not yet been identified (Bellinder et al., 1999).

3. Continue Reducing the Use of Organophosphate Insecticides

In 1998, organophosphates still accounted for 54% of insecticides used in vegetables in New York. Methamidophos in potatoes and dimethoate in cabbage accounted for much of this organophosphate use (Table 5). Since 1998, several organophosphates (methyl parathion, dyfonate, disulfoton) have lost their registrations in the U.S. or are being phased out. Several new classes of insecticide chemistry, including neonicotinoids, avermectins, spinosyns, fiproles, *Bacillus thuringiensis*, and various insect growth regulators have spawned a variety of new and effective substitutes for organophosphates for control of insect pests in vegetables. Furthermore, increasing the use of seed treatment formulations of insecticides rather than sprays should further reduce the amount of insecticide active ingredient applied to vegetables (Taylor, Eckenrode, & Straub, 2001; Kuhar, Stivers, Hoffmann, & Taylor, 2002).

Table 5.
Pesticides with the Highest Statewide Application in New York Vegetables in 1998

Pesticides	Total Applied (kg)	Primary Crops (% of total)
Fungicides		
mancozeb	206,738	potatoes (65%), onions (31%)
chlorothalonil	123,888	onions (34%), potatoes (30%), cabbage (11%)
captan	95,905	potatoes (88%)
maneb	90,559	potatoes (54%), onions (37%)
fixed copper	30,537	potatoes (46%)
metiram	24,058	potatoes (100%)
Herbicides		
metolachlor	71,890	sweet corn (48%), potatoes (15%), dry beans (15%), snap beans (10%)
EPTC	68,612	dry beans (55%), snap beans (37%)
chlorpropham	26,314	potatoes (100%)
pendimethalin	25,203	onions (67%)
bentazon	21,817	sweet corn (42%)

atrazine	20,546	sweet corn (100%)
alachlor	15,843	sweet corn (100%)
maleic hydrazide	14,655	potatoes (51%), onions (49%)
trifluralin	13,549	dry beans (33%), snap beans (29%), cabbage (25%)
glyphosate	8,314	potatoes (68%)
cyanazine	7,921	sweet corn (100%)
metribuzin	7,390	potatoes (92%)
Insecticides		
cryolite	20,675	potatoes (100%)
dimethoate	16,538	cabbage (59%), potatoes (38%)
methamidophos	14,285	potatoes (100%)
B. thuringiensis	10,060	cabbage (99%)
chlorpyrifos	10,010	onions (56%), cabbage (30%)
disulfoton	8,432	potatoes (45%)
phorate	6,637	sweet corn (60%)
endosulfan	6,417	potatoes (44%)
carbaryl	5,974	pumpkins (34%), squash (25%)
methyl parathion	5,172	sweet corn (96%)
terbufos	5,149	sweet corn (100%)
thiodicarb	4,159	sweet corn (100%)
acephate	3,394	snap beans (42%), peppers (35%)
carbofuran	3,221	sweet corn (92%)

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