Cover-cropping Practices of Vegetable Producers in Western New York

Lydia J. Stivers-Young¹ and
Frances A. Tucker²

ADDITIONAL INDEX WORDS. oats (*Avena sativa*), rye (*Secale cereale*), clover (*Trifolium pratense*), sudangrass (*Sorghum sudanense*), barley (*Hordeum vulgare*), hairy vetch (*Vicia villosa*), ryegrass (*Lolium multiflorum*), wheat (*Triticum aestivum*), alfalfa (*Medicago sativa*)

SUMMARY. Surveys of vegetable growers in a six-county region in western New York were conducted in 1997 to determine which cover cropping practices were being used on commercial vegetable operations; to identify producers' needs for further research and information, and to assess the impact of cooperative extension programs in this area. In a broad survey, 118 responses were returned out of 315 surveys sent (37%). Respondents represented >37,000 acres (14974 ha) of vegetable production, or ≈53% of the vegetable acreage in the region. Vegetable acreage per operation ranged from 1 to 4000 acres (0.4 to 1619 ha). Sixty-nine percent responded that they grew cover crops on a total of 15,426 acres (6243 ha). Oats (*Avena sativa* L.), rye (*Secale cereale*), clover (*Trifolium pratense*), and wheat (*Triticum vulgare*) were the most commonly used cover crops. Seventy-six percent of the reported cover-cropped acres were planted to small grains, and 19% to legumes, almost entirely clovers. In open ended questions, the most important benefits

of cover cropping identified by respondents were erosion control (46% of respondents) and organic matter additions (42%). The most important problems associated with cover crops were that they interfere with spring field work or fall harvest (26%), and that they are difficult to incorporate or plow under (24%). A targeted survey of nineteen onion (*Allium cepa* L.) producers in the same region measured the recent adoption of sudangrass (*Sorghum sudanense* Piper) and sorghum-sudan hybrid (*Sorghum bicolor* L. x *S. sudanense*) cover crops, the focus of the several years of extension research and educational programs. Nine of the onion producers had adopted the practice, and six of these had done so since the beginning of these extension programs. The implications of these results for research and extension are discussed.

Agricultural science literature is filled with reports on the beneficial aspects of cover crops in farming systems, both for environmental conservation and for improving and maintaining productivity (Bruce et al., 1991; Drinkwater et al., 1998; Meisinger et al., 1991; Staver and Brinsfield, 1998). The core of this knowledge is not new; the ancient Romans understood the importance of rotating edible crops with forage legumes. Field studies in Europe and the United States after the turn of the century began to provide a scientific basis for promoting the practice (Barron, 1925; Pieters, 1927), and the dustbowls of the 1930s underscored the importance of vegetative cover for cultivated land. Less attention was paid to cover crops with the advent of chemical fertilizers after World War II. But since the mid-1980s, increased interest in the sustainability of agriculture has spawned a great deal of research in expanding the use of cover crops in existing and evolving production systems, especially those involving conservation tillage (Blevins et al., 1990; Sainju and Singh, 1997).

Cover cropping is particularly appropriate for vegetable production systems which typically leave few surface residues for erosion protection (Bellinder and Gaffney, 1995), return little organic matter to soils, and are often associated with soil structural problems that can severely limit productivity (Wolfe et al., 1995). Cover crops can be used to help mitigate these problems, as well as to manage pest such as weeds and

diseases (Creamer et al., 1995; Viane and Abawi, 1998). However, some cover crops can exacerbate vegetable pest problems (G.S. Abawi, personal communication). Climate and geography can be important factors determining cover-cropping practices of vegetable producers. Growers in the northeastern U.S. are somewhat limited in their cover-cropping options by a short growing season (Stivers-Young, 1998).

Growers often take many diverse factors into account when making management decisions such as what types of cover crops to grow, how much acreage to devote to cover crops, and how to manage them. As new information becomes available on the benefits of cover cropping, on new cover crop species or cultivars, and on successful methods for managing cover crops, it is useful to document the actual practices of growers, as well as their reasons for adopting or not adopting cover crops. This information can be used to direct or refine research, and to identify opportunities for extending current knowledge.

In this study, commercial vegetable producers in six western New York counties were surveyed about their cover cropping practices, and perceived benefits and drawbacks of cover cropping. The objectives were to determine which cover-cropping practices and species are being used on commercial operations; to identify producers' needs for further research and information; and to measure the impact of cooperative extension programs in this area.

Materials and methods

One broad and one targeted survey of commercial vegetable growers in a six-county area in western New York were conducted in 1997. The broad survey was a questionnaire consisting of both multiple choice and open ended questions (Table 1), and was mailed to 315 commercial vegetable growers enrolled in cooperative extension in Monroe, Genesee, Orleans, Niagara, Erie, and Chautauqua counties. These six counties lie along the southern shore of Lake Ontario and eastern shore of Lake Erie, and contain >70,000 acres of commercial vegetables, ≈35% of the state's total vegetable acreage (U.S. Dept. of Commerce, 1992). A single mailing was done on 17 Nov. 1998, and responses were collected for a period of 8 weeks after the mailing.

No definition of cover crops was included in the survey, allowing respon-

Cornell Cooperative Extension, 249 Highland Ave., Rochester, NY 14620.

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¹Area extension specialist.

²Program assistant.

Table 1. Questionnaire for survey of cover cropping practices of vegetable producers in western New York.

1. Please record your yearly average acreage of all vegetables (including dry beans).
2. Please check which of the following vegetable crops you grow:

cabbage	tomatoes
sweet corn, fresh	peppers
sweet corn, processing	pumpkins
snap beans, fresh	cucumbers, melons, squash
peas	lettuce or leafy greens
beets or carrots	potatoes
dry beans	onions
3. Do you currently use cover crops in your vegetable rotation?

Yes (go to #5)	No (go to #4)
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4. If you checked no in #3, please rate your interest level in the use of cover crops:

Will probably use soon	Might use; some interest	Not interested
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5. If you checked yes in #3, then:
 - When did you start using cover crops?

before 1990	between 1990–95	since 1995
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 - Which cover crop(s) do you currently use? If you use more than one, please estimate the acreage of each cover crop planted:

Cover crop 1 _____	Acreage _____	Month planted _____
Cover crop 2 _____	Acreage _____	Month planted _____
6. Please list the top three benefits and the three problems you see to using cover crops in your operation:
7. How useful to you is Cornell Cooperative Extension as a source of information about cover crops?

Very useful	Somewhat useful	Not useful
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8. Do you have questions about cover crops which you would like to see addressed in the future? How might this information best be conveyed to you:

Grower meeting	Newsletter article	Other (please describe)
Bulletin		
9. Additional comments:

dents to rely on their own definitions. No mention was made in the survey of specific cover crop species, nor of particular benefits or problems associated with cover cropping.

A smaller, targeted survey of onion growers in Orleans and Genesee counties was conducted during the same months. There are ≈2500 acres (1012 ha) of onions grown on muck (organic) soils in these two counties, representing a crop value of over \$8 million (New York Agricultural Statistics Service, 1997). The survey was first mailed to all sixteen onion growers in the area, and nonrespondents were later contacted by phone or by a personal visit. This survey asked the following questions: "Do you grow sudangrass or sorghum-sudangrass hybrid cover crops?" "If yes, how many acres this year?" and "What was the first year you grew this cover crop?" The specific objective of this smaller survey was to measure the adoption of one cover-cropping practice, using sudangrass and sorghum-sudan hybrid cover crops in rotation with muck-grown onions. Research has shown that these cover crops can improve subsequent onion crop yields by breaking pest life cycles and improving soil structure (Mishanec, 1998). This practice had been the topic of numerous research projects, demonstrations, and educational programs conducted by

Cornell Cooperative Extension during the years 1993–97.

Results

In the larger survey, 118 responses were returned out of 315 surveys sent, for a 35% response rate. However, respondents represented 37,093 acres (15,012 ha) of vegetable production,

or 53% of the commercial vegetable acreage in the six-county region. Potatoes (*Solanum tuberosum* L.) and edible dry beans (*Phaseolus vulgaris* L.) are both considered vegetables for purposes of this study. In the smaller survey, answers to questions were obtained from eighteen of the nineteen onion growers.

Fig. 1. The frequency distribution of respondents per size class of total vegetable acreage is shown by columns. Each column is divided into self-identified cover crops growers (dark portion) and noncover crops growers (light portion). Numbers on top of columns indicate the average cover cropped acreage, for those who do cover crop, within each size class of vegetable acreage (1 acre = 0.405 ha).

Fig. 2. Frequency distribution of specific vegetable crops grown by respondents is shown by columns. Each column is divided into self-identified cover crops growers (dark portion) and noncover crops growers (light portion).

CHARACTERISTICS OF RESPONDENTS. Respondents to the larger survey represented a wide range of vegetable operation sizes, from a minimum of 1 acre (0.4 ha) to a maximum of 4000 acres (1619 ha) of commercial vegetable production (Fig. 1). Just over half of respondents produce 100 acres (40.5 ha) of vegetables or less, and 9% produce >1000 acres (405 ha).

Consistent with the wide range of acreage, respondents produce a wide variety of vegetable crops (Fig. 2). In this region, vegetables are produced for processing markets [peas (*Pisum sativum* var. *arvense* L.), sweet corn (*Zea mays* var. *rugosa* Bonaf.), snap beans (*Phaseolus vulgaris* L.), potatoes, beets (*Beta vulgaris* L. Crassa group), carrots (*Daucus carota* L.), and dry edible beans], for storage [potatoes, onions, cabbage (*Brassica oleracea* L. Capitata group)], and for fresh market wholesale and direct marketing channels [primarily sweet corn, cucurbits, tomatoes (*Lycopersicon esculentum* Mill), peppers (*Capsicum annuum* var. *annuum* L.), and various other vegetables]. The vegetables grown by the highest number of respondents, including fresh market sweet corn, tomatoes, pumpkins (*Curcubita pepo* L. var. *pepo*) and other vine crops, are all important fresh market crops. Producers grow-

ing for the fresh market tend to have smaller and more diversified operations compared to processing and storage crop growers. In the surveyed region, ≈60% of the vegetable acreage is devoted to processing crops, 20% to storage crops, and 20% to fresh-market crops (U.S. Dept. of Commerce, 1994).

COVER CROPS GROWN. Adoption of cover cropping was measured by several questions in the broad survey. Respondents identified themselves as cover crop growers or nongrowers in Question 3, and provided details on species planted, acreage per cover crop species, month planted, and what year they began growing cover crops.

Sixty-nine percent of all respondents indicated that they do grow cover crops. Of those growing cover crops, 79% began the practice before 1990, 15% began between 1990 and 1995, and 6% had starting cover cropping since 1995.

The proportion of cover crop growers vs. noncover crop growers based on the size of the vegetable acreage and on the vegetable crops produced are shown in Figs. 1 and 2, respectively. Seventy-five to eighty percent of respondents with vegetable acreage between 26 and 1000 acres (10.5 and 405 ha, respectively) grow cover crops. Only 46% of those with

25 or fewer acres (10 ha) cover crop, while 90% of those with >1000 acres (405 ha) grow cover crops.

The proportion of respondents who grow specific vegetable crops and who also grow cover crops is shown in Fig. 2. However, this data does not indicate whether or not cover crops are grown specifically for the benefit of, or in rotation with, each specific vegetable crop. The percent of producers who grow specific vegetable crops who also grow cover crops ranged from 61% (processing sweet corn) to 87% (processing snap beans). No class of vegetable crops (processing, storage, or fresh market) tended to show obvious higher or lower rates of cover cropping.

Growers reported planting cover crops on a total of 15,426 acres (6243 ha; Table 2). Because the terms vegetable crops and cover crops were self-defined, the total cover-cropped acreage is not simply a subset of the total vegetable acreage. In some cases, growers responded that they grew more acres of cover crops than of vegetables, indicating that either they did not consider the cover-cropped acreage part of their vegetable acreage, or that they were reporting cover crops grown for vegetables as well as other crops.

Oat cover crops were the highest in terms of acres planted, followed by grain rye, red clover, and wheat. Rye was planted by the largest number of growers (44), followed by wheat, red clover, and oats. The largest acreages of cover crops per operation were rye [1300 acres (526 ha)] and oats [1250 acres (506 ha)].

Seventy-six percent of the total reported cover-cropped acres were planted in the small grain crops of rye, oats, wheat, and barley (*Hordeum vulgare* L.). Legumes [red clover, alfalfa (*Medicago sativa* L.), and rye plus hairy vetch (*Vicia villosa* Roth)] were planted on 19%, with the remaining 5% in sudangrass, ryegrass (*Lolium multiflorum* Lam.), and buckwheat (*Fagopyrum esculentum* Moench) combined. Sudangrass and sorghum sudangrass hybrids constituted less than 3% of the cover cropped acres, but were grown by 10% of respondents.

Oats, rye and wheat are planted most frequently in September and October, and clovers are planted mostly in March and April (Table 2). About 80% of the acreage is planted to cover crops which grow primarily in fall,

Table 2. Cover crops grown on commercial vegetable operations in western New York.

Cover crop	Acres planted ^z	Cover cropped acreage (%)	Growers (no.)	Mean acres/ Grower ^y	Range (acres) ^z	Months planted ^x
Oats	4007	26.0	18	236	1-1250	7, 8, 9, 10, 11
Rye (grain)	3727	24.2	44	89	2-1300	7, 8, 9, 10, 11
Clovers	2728	17.7	19	152	7-700	2, 3, 4, 5
Wheat	2640	17.1	22	125	1-500	7, 8, 9, 10, 11
Barley	1374	8.9	9	172	50-650	4, 5, 7, 8, 9, 10
Sudangrass ^w	414	2.7	12	35	3-100	5, 6, 7
Ryegrass	338	2.2	5	68	8-200	8, 9
Alfalfa ^v	99	0.6	5	20	6-60	4, 5, 8
Rye and hairy vetch	95	0.6	2	47	40-55	8, 9, 10
Buckwheat	4	< 0.1	2	2	1-3	6, 7, 8
Total	15,426 acres		81 ^u			

^z1 acre = 0.405 ha.^yAverage size of planting, in acres, based on number of growers who supplied acreage information.^xMonths in which growers reported planting cover crop (1 = January, 2 = February, etc.). Months shown in bold were those most frequently indicated.^wIncludes sorghum-sudangrass hybrids.^vSelf-described as using alfalfa as a cover crop. It is likely that this is only a small proportion of the total acreage of alfalfa planted by this group of growers, most of whom do not consider it a cover crop per se.^uOf a total of 118 responses, 81 producers indicated that they do grow cover crops.

winter, and early spring. Of the cover crops identified by respondents, only clover and sudangrass, representing 20% of the acreage, are grown primarily during the summer months. Clover is often left to grow for an entire year.

The relationship between the vegetable crops and the major cover crops grown by respondents is shown in Table 3. In general, wheat tends to be favored by processing vegetable and cabbage producers; rye is favored by fresh market vegetable producers; clovers by dry bean and processing sweet corn growers. Barley is grown mostly by onion producers.

BENEFITS AND PROBLEMS IDENTIFIED. Both cover-crop growers and nongrowers responded to survey ques-

tions about benefits and problems of cover cropping. Benefits and problems identified by producers were grouped into similar responses (Tables 4 and 5). There is some overlap in these response classes, but attention was paid to maintaining the emphasis of each response when grouping them. The most important benefits of growing cover crops cited were erosion control (both wind and water erosion) and adding organic matter. Weed suppression and the addition or conservation of nutrients were also frequently noted benefits although few identified reduction of insect and disease pressure as significant. Benefits in the areas of soil structure (soil tilth, soil compaction, and drainage) were also important.

While there were a total of 219 responses to the benefits question, the question on problems associated with cover cropping elicited only 112 responses (Table 5). The most important problems indicated were that cover cropping interferes with spring field work and/or fall harvest (interferences in spring and fall were cited in equal numbers) and that growers sometimes experience difficulty with incorporating or plowing under a cover crop. Cost in labor, materials and equipment were frequently noted as drawbacks.

EXTENDING INFORMATION. Forty-four percent of respondents find Cornell Cooperative Extension very useful as a source of information, and an additional 36% find extension some-

Table 3. Number of respondents growing vegetables and most common cover crops.

Vegetable crop	Cover crop				
	Wheat	Rye	Oats	Clover	Barley
Potatoes	2	9	4	3	2
Onions	2	8	2	1	6
Lettuce or leafy greens	1	12	4	2	1
Cucurbits (not pumpkins)	9	25	9	5	1
Pumpkins	7	26	6	4	2
Peppers	7	19	7	2	1
Tomatoes	9	26	7	5	1
Dry beans	5	8	3	10	2
Beets or carrots	5	14	6	3	1
Peas	13	18	9	8	3
Snap beans, processing	9	5	6	3	1
Snap beans, fresh market	2	13	2	1	1
Sweet corn, processing	9	7	8	7	3
Sweet corn, fresh market	9	26	8	4	3
Cabbage	10	18	7	2	2

Table 4. Benefits of using cover crops as indicated by respondents; 219 total responses were given. Benefits representing <1% of responses are not shown.

Benefits of using cover crops indicated by respondents	Response (%)
Erosion control, including windbreaks for wind erosion	25
Adds organic matter	23
Weed control	15
Adds or conserves nutrients such as nitrogen	14
Improves soil tilth, makes plowing easier	9
Reduces soil compaction	5
Reduces insect and disease pressure	2
Conserves soil moisture	2
Produces better crop growth and yield	2
Conserve water quality and reduce runoff	1

what useful as a source. Growers were most interested in receiving cover crops information in written form: 35% selected "newsletter article" and 23% selected "bulletin" as the preferred method for conveying the information, compared to 14% who selected "grower meeting."

In the Additional Comments section of the survey, respondents made a wide variety of comments on research, information, and technical needs. Several mentioned that they have been using cover crops for many decades. With the exception of those using sudangrass, very few growers are planting cover crops other than conventional small grains and legumes. However, five growers specifically requested more research and information on alternative cover crops such as hairy vetch, mustards (*Brassica juncea* L. and *B. hirta* Moench), fescues (*Festuca* sp.), and sudangrass. Several also wanted to know more about how different cover crops affect weeds, diseases, and insect pests of vegetable crops. Others asked for information on integrating cover crops into their specific cropping practices, such as options for late seeded cover crops, potential herbicide effects in interseeding legumes in sweet corn, and options for perennial crops.

SURVEY OF ONION GROWERS. In the survey of onion growers, nine indicated that they now regularly use sudangrass or sorghum-sudangrass hybrid cover crops in rotation with onions. Of these nine, three began growing sudangrass cover crops in the mid-1980s, when the first cooperative extension trial with sudangrass was conducted in the area. The remaining six growers have begun using sudangrass since 1995. In 1997, >200 acres (81 ha) of sudangrass were planted on muck soils in the surveyed area.

Discussion

The degree of adoption of a conservation practice such as cover cropping depends on many factors (Duff et al., 1991) including the costs, perceived benefits, level of knowledge about the practice, availability of equipment and labor, etc. In this study, commercial vegetable growers in western New York exhibited a high degree of adoption of the practice of cover cropping, both in the proportion of growers (69%) and the acreage devoted to cover cropping. A few published reports of cover-crop adoption rates among farmers exist in the literature. According to Drost et al. (1997), only 25% of vegetable growers in Utah practice cover cropping. Researchers from the Maryland Department of Agriculture found that among a surveyed group of farmers in the state, 60% had grown cover crops at some time over the preceding ten years (Maryland Department of Agriculture, 1997). Forty-two percent of surveyed field crops producers in Ontario reported that they use plowdown crops as an erosion control practice (Duff et al, 1991). Glynn et al. (1995) found that 80% to 88% of cabbage growers

and 91% to 97% of onion growers in New York State planted cover crops. In that study, adoptors of integrated pest management (IPM) were somewhat more likely to cover crop than nonadoptors.

The apparent trend that producers with larger vegetable acreage are more likely to grow cover crops may be explained by their greater opportunity to rotate acres away from cash crop production and put it into cover crops. However, the average number of cover cropped acres per size class (Fig. 1) tends to fall from the median [13 acres (5.3 ha) in the 1 to 25 acre class] toward the minimum [956 acres (387 ha) in the 1001 to 4000 acre class] of each size class as vegetable acreage increases. This suggests that while large-scale growers may be more likely to cover crop at least some portion of their acreage, smaller scale growers may be devoting a larger percentage of their acres to cover crops.

Cover crop species selection would be expected to vary regionally. In contrast to western New York, growers in Maryland grow very little oats as a cover crop (Maryland Department of Agriculture, 1997). However, similar to New York, small grains are still the dominant type of cover crop grown in Maryland, with rye, wheat, and barley being the predominant species.

Legumes are of much less significance than small grains in New York, and are comprised almost exclusively of clover. Red clover is often frost-seeded into wheat grown as a cash crop, allowed to grow after wheat harvest in July, and incorporated the following spring. This takes advantage of an otherwise fallow period during warm growing conditions following wheat harvest. Wheat is a common rotation crop for vegetables in this region, and

Table 5. Problems with using cover crops as indicated by respondents; 112 total responses were given. Problems representing <1% of responses are not shown.

Problems with using cover crops indicated by respondents	Response (%)
Interferes with spring field work and/or fall harvest	31
Difficulty with incorporating cover crop or plowing	25
Too costly (labor, materials, and/or equipment)	14
Retains soil moisture and limits soil warming in spring	9
None	4
Weed or insect problems	4
Not compatible with weed control program	3
Cover crop doesn't winter kill	3
Not enough growth	3
Finding source for seeds	2
Robs soil of moisture for cash crop	2

may be used either as a cover crop (i.e., incorporated rather than harvested) or a cash grain crop, depending on market prices and other factors. Even if used as a cash grain, a wheat crop usually provides excellent erosion protection over the winter (Bellinder and Gaffney, 1995). Because survey respondents were not given a specific definition of the term cover crop, it is likely that some acres reported here as wheat cover crops may have been harvested, and that not all wheat planted by respondents was reported here as a cover crop. Similarly, alfalfa is rarely grown simply as a cover crop, but as a rotation crop which is mowed for harvest. Alfalfa requires at least a year and a half for establishment and significant growth, making it a very expensive cover crop choice.

Oats, the most predominant cover crop in terms of acreage, are planted mostly in September and October, and typically winter kill, leaving an easily tillable surface residue (Stivers-Young, 1998). Grain rye is the most predominant cover crop in terms of numbers of growers, especially among fresh market vegetable producers. This is probably because rye can be planted later in the season (through much of October) than other cover crops and still result in significant groundcover. Barley is used primarily by onion growers as a wind break at onion seeding, and is typically killed using a selective herbicide within a month of planting.

As vegetable production systems change in response to technological, demographic, economic and other factors, the use of less well known cover-crop species may become more appropriate. Advances in crop breeding may improve the agronomic characteristics or pest-suppressive effects of cover crops previously deemed unsuitable for widespread use. Over the past 5 years, a number of Cornell Cooperative Extension research projects and educational programs have focused on new cover crop species including hairy vetch, sudangrass, sorghum-sudan hybrids, and various brassica cover crops such as Indian mustard (*Brassica juncea* L.), yellow mustard (*Brassica hirta* Moench) and oilseed radish (*Raphanus sativus* L. var. *oleifera*). Sudangrass and hairy vetch were once commonly used in New York (Barron, 1925) while the use of brassicas as cover crops is new. The adoption of sudangrass and sor-

ghum-sudan hybrids among onion growers, the major targeted audience, has been relatively high, especially considering that valuable land must be taken out of production for an entire year. Most growers have adopted the practice recently, likely responding at least in part to extension programs. Research on brassica cover crops is still ongoing, and only a handful of producers across the state have experimented with these. However, there seems to be potential in focusing extension efforts on the adoption of hairy vetch, which has been field tested repeatedly in the northeastern U.S. (Mangan and Herbert, 1992), and may provide different benefits than small grains (Waggoner et al., 1998). One obstacle to the adoption of hairy vetch is the cost of seed, which can be as much as three times the cost of small grain cover crops on a per acre basis (Mallory et al., 1998). Growers can produce their own seed relatively easily, although land producing seed is not available to produce vegetables.

The benefits of cover cropping identified by growers in this survey (Table 4) are consistent with reports of growers' reasons for cover cropping in other regions of the country. A small number of cash grain farmers cooperating in on-farm research in Wisconsin identified erosion control as the leading reason that they considered using cover crops (Mallory et al., 1998), as did farmers in the Maryland study (Maryland Department of Agriculture, 1997). Wisconsin farmers also indicated that N benefits were an important factor in their decision, although the economic analysis of the cover cropping practices used in that study indicated that cover crop N was at least three times as expensive as fertilizer N. Costs, both direct and indirect, were the most important concern expressed by these farmers. Maryland farmers also identified improvements in soil tilth as an important effect of planting cover crops.

The identified benefits are also attainable with the predominant cover crops used by these producers. Erosion control and the addition of organic matter were the most important benefits identified by this population of growers, and these are both very important concerns for vegetable soils in New York (Wolfe et al., 1998). Small grain cover crops are well known for their ability to control erosion

(Langdale et al., 1991) and supply organic carbon (Reicovsky and Forcella, 1998).

No grower specifically mentioned the improvement of soil biological activity as a benefit of using cover crops. This is a difficult characteristic for producers to assess but has recently been recognized as a very important component of soil quality (Romig et al., 1995; Walter et al., 1997). Increasing the use of N-rich legume cover crops relative to carbonaceous small grains may help growers improve the biological activity of their soils, beyond effects of added nitrogen from legumes (Andren et al., 1988; Waggoner et al., 1998). In addition, while only three respondents mentioned the conservation of water quality and runoff reduction, small grain cover crops are probably significantly contributing to cleaner surface and groundwater where they are being used (Staver and Brinsfield, 1998; Meisinger et al., 1991). This benefits not just area producers, but society as a whole.

IMPLICATIONS FOR RESEARCH AND EXTENSION. This study has provided evidence that producers in New York value the information and expertise offered by cooperative extension, and do adopt new practices in response to Extension programs. Results of this survey point out a number of further opportunities for research and extension efforts toward the adoption of appropriate cover crops and improvement of cover crop management among commercial vegetable growers in New York.

- More research and demonstrations are needed on newer cover crops such as hairy vetch, brassicas, and sweet clovers (*Melilotus* sp.) to better understand their potential suitability to New York growers. Information on how these and other cover crops perform in mixtures compared to monocultures would also be useful. Participatory research approaches actively involving growers may speed appropriate adoption of these cover crops.
- Many growers identified interference with fall harvest as a significant problem, and late vegetable harvest is undoubtedly an important obstacle in greater adoption of cover cropping in this region. More research and demonstrations should be conducted on ways to

get cover crops established earlier in the fall without interfering with vegetable crop harvests, such as overseeding or late interseeding.

- Research on ways to mechanically and/or chemically manage cover crops in spring to minimize the interference with spring field work and ease incorporation may facilitate further adoption.
- Educational programs should be designed with the understanding that the cover crop needs of small farmers may be different from those of larger farmers. The objective for small farms might be to simply get started growing cover crops, while the objective for larger farms might be to find ways to expand acreage already being cover cropped. Written materials remain useful methods for conveying cover crops information to farmers.
- Society benefits from the environmental stewardship practices of area growers. Greater efforts should be made to educate the general public about these benefits.

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