Conclusions

These survey results suggest a number of factors to consider in designing research and educational programs to prevent or reduce the potential for pollution of surface water and groundwater by fertilizers applied to lawns and ornamental landscapes. Communicating via commercial sales representatives and popular trade magazines is currently the most efficient way to reach maintenance firms. The forms and amounts of fertilizers typically used by the industry appear appropriate. The best approach to prevent P pollution from landscapes is to ensure that soil particles with associated nutrients do not wash off of the site. It would be interesting to determine how operators reconcile their scheduling, observation, and soil test information to determine when and how much to fertilize and to test the appropriateness of the derived fertilizer application schedule. Most operators apply the bulk of N in the spring, with additional N applied in summer and fall; most of the P is applied in the fall and spring. Finally, relatively few operators offered an organic fertilizer option and even fewer customers purchased such an option. This may be due to availability, aesthetic problems, high transportation and application costs of organic fertilizers, or a lack of information. In contrast, operators and customers indicated that information concerning conventional fertilization was adequate.

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Utah's Vegetable Growers: Assessing Sustainable Agriculture

Daniel Drost,[1] Gilbert Long,[2] and Kimberlee Hales[3]

ADDITIONAL INDEX WORDS. survey

SUMMARY. Without a clear understanding of individual farms and farming practice, progression toward more sustainable vegetable production cannot occur. Seventy randomly selected vegetable farmers in Utah were surveyed by telephone and mail to gather baseline data on their agricultural practices. The Utah vegetable farmers profile generated by this survey included a measure of each respondent's attitude toward sustainable agricultural practices and his or her interest in further cooperation with research and extension. A farming index to measure practices used and a perceptual index measuring farmer's views regarding sustainable practices were developed, pilot tested, and refined during the project. Although the perceptual index did not serve as a proxy for actual farm practice, it identified farmers who had an appreciation for sustainable agriculture. Together with the farming index, we now have detailed information on actual farm practices for a variety of different vegetable farmer groups. The use of these two indices will help measure the effectiveness of future research and extension efforts as farmers progress toward more sustainable vegetable production.

Traditional research and extension efforts have not met the needs of Utah's vegetable industry. Extension programs have historically focused on the progressive farmer with the expectation that adopted technology will diffuse to other farmers. This, however, assumes that there is a homogeneous population of farmers. A previous study of sustainable farmers in Utah demonstrated that small part-time farmers outnumber large influential, progressive farmers (Drost et al., 1996). While some diffusion occurs from the progressive farmers to small part-time farmers, targeting extension to representatives of homogeneous subgroups increases the speed of the diffusion process regardless of farm size (Roling, 1988). Since different commodities have different cultural practices, it is important that the farming system of each be understood before corrections or changes can be implemented. At the same time, agricultural extension needs to balance traditional

Utah State University, Logan, UT 84322-4820.

[1]Assistant professor and extension vegetable specialist, Plants, Soils and Biometeorology Dept.

[2]Professor, Agricultural Systems Technology and Education Dept.

[3]Research assistant, Agricultural Systems Technology and Education Dept.

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programs with new initiatives if farmers are to maintain their ways of life and be truly sustainable (Keeney, 1990; Roberts and Lighthall, 1993). Sustainable agriculture by definition is a dynamic set of practices and technologies that minimize damage to the environment while providing income to the farm over a long time span (Flora, 1992). By understanding the individual farm and accepting that sustainability is a dynamic system, research and extension needs to identify farmers who are receptive to or in need of change. Therefore, the objectives for this study were to establish baseline descriptors and assess the sustainable agricultural practices of Utah's vegetable farmers.

Materials and methods

From a target population of 310 possible vegetable growers in Utah, a random sample of 170 was drawn of

Table 1. Point values for farming practices used. These values were summed to create a farming index.

Farming practice	Points
I. Integrated pest management	(a + b = 25 points)
A. Crop rotations	8
B. Chemical use on pests (diseases, insects and weeds)	
1. Limits use	4
2. Scouts for pests	2
3. Sprays only when pest level threatening	4
4. Uses natural predators	2
5. Sprays used for pests (no.)	
a. 0–5	5
b. 6–11	3
c. ≥12	1
II. Nutrient management	(a + b + c + d + e = 34 points)
A. Soil tests	
1. Use soil tests	2
2. Soil test frequency	
a. Every year	3
b. Every other year	2
c. Occasionally	1
B. Use of on-farm inputs	
1. Animal manure–compost–organic fertilizer	3
2. Green manure–cover crops–alfalfa plowdown	3
C. Nutrient crediting	
1. Credit b.1	5
2. Credit b.2	5
D. Crop rotations	
1. Rotate crops	1
2. Use legume crop rotation	4
E. Irrigation	
1. Application method	
a. Flood or furrow	1
b. Sprinkler	3
c. Trickle	5
2. Application rate known	3
III. Field operations	(a + b + c + d = 20 points)
A. Field preparation—number of tillage operations	
1. 0–2	5
2. 3–5	3
3. ≥6	1
B. Planting—number of passes	
1. 1	5
2. 2–3	3
3. ≥4	1
C. Harvest—number of operations	
1. 1	5
2. 2–3	3
3. ≥4	1
D. Weed control—number of cultivations	
1. 0–2	5
2. 3–6	3
3. ≥7	1

which 99 were found to be active producers. A 45-question telephone survey and a 36-question mail survey were used to gain information about growers' opinions of certain agricultural practices and the actual practices used in nutrient management, field operations, and integrated pest management (IPM). Seventy producers (72%) responded to our telephone survey and 50 of these (71%) returned the follow-up survey.

To assess a farmer's knowledge and attitude toward selected conservation practices, a perceptual index was designed consisting of a series of paired questions (Oppenheim, 1966). The questions dealing with the similar issues were worded in a way to elicit responses with varying degrees of agreement or disagreement. The questions were used to categorize farmers into groups with similar attitudes and create a continuum in relation to each other. The paired questions dealt with common farming issues related to nitrogen use, crop rotations, pesticide applications, nutrient cycling, manure use, and erosion control. The survey participants were asked if they strongly disagreed, disagreed, were neutral, agreed, or strongly agreed with statements concerning common agricultural practices. The questions were scored and summed to determine the individual's rating and assess if the respondents had interest in, knowledge of, or opinions on sustainable agricultural practices. This index was also developed to assess if a short questionnaire would act as a proxy for a more detailed evaluation of individual farming practices.

In addition, a detailed farming index representing the farming practices used by each respondent was formulated (Table 1). The index used a weighted scale to determine if the practices used by farmers were sustainable. The scale is an attempt to rank growers and categorize them as being more or less sustainable. The farming practices evaluated were field operations (number and type), nutrient management issues (inputs, crediting and soil testing), and pest management (chemical use) practices. The farming index, together with the actual practices used by growers, will serve as baseline data for future evaluation of extension–research efforts toward adoption of more sustainable practices used by Utah vegetable growers. Pearsons correlation was used to compare the perceptual index and the farming index to years farming, income derived from vegetables, education level, growers age, and land farmed.

Results and discussion

Utah grew 7500 acres of fresh-market vegetables in 1995 (Utah Agricultural Statistics Service, 1996). The demographics of the Utah vegetable industry are presented in Table 2. Utah's vegetable growers farm an average of 45 acres (range 1 to 600) in their primary (anchor) vegetable. Almost 30% reported an anchor crop between 1 and 9 acres, with 10% farming >100 acres. The vegetables grown include, but are not limited to, asparagus, cabbage, chili peppers, garlic, green beans, melons, onions, peas, potatoes, pumpkins, sweet corn, and tomatoes. Most growers raised several different vegetables on their farms. Fifty-four percent of the growers owned 50% or more of their vegetable crop acreage, while 46% rented 50% or more of their cropland. A typical Utah vegetable grower is male (96%), 51 years old, owns more than half of his land and has farmed for 33 years. Almost all (97%) had a high school education and 30% had at least a bachelors degree. Thirty-four percent can be considered small part-time farmers, as they reported earning >75% of their total income from other sources. Twenty-five percent said they earned >75% of their income from vegetables.

Field operations vary from crop to crop (Table 3). On average, four passes were made to prepare fields for planting (primary operations), although 31% of the respondents indicated they made 6 to 12 passes. In our judgment, this makes these farmers good candidates for extension efforts to reduce tillage. Secondary field operations (planting, cultivation, and harvesting operations) varied depending on the crop grown. Onions and melons required more secondary field operations than sweet corn. On average, vegetable growers performed 6 secondary field operations (range 2 to 7). Of those crops surveyed, onion growers use the most chemicals while melon growers use the least. Most of the chemicals used to grow vegetables are to control weeds and insects. In general, disease pressure is low due to Utah's dry climate, so few treatments are required. Most respondents had heard of IPM but only 48% used IPM techniques on their farms. Most growers stated that they scout for insects or weeds but continue to use chemical sprays to control these problems. Grower adoption of practices that reduce field operations and spray use would save time, money, and chemical inputs to the farming system without reducing yield. Although IPM practices have been strongly emphasized in Utah, adoption of IPM does not appear evident among Utah vegetable growers. Clearly farmers develop and use cultural practices in which they are comfortable. This minimizes production risk associated with crop failure or yield reductions.

All Utah vegetable growers use synthetic fertilizers in addition to alternative nutrient sources like animal or green manure and alfalfa plowdown (Table 4). While many growers use alternative nutrients (81%), few (25%) credit the

Table 2. Demographics and acreage of Utah vegetable growers by crop.

	Vegetable farmer demographics						Acres (%)	
Crop	Male (%)	Age	Education	Income[z]	Years farming	Acres	Owned	Rented
Onions	100	47.5	post-HS[y]	51	31	62	46	54
Sweet corn	90	54.0	post-HS	41	36	31	62	38
Melons	85	54.0	post-HS	53	34	21	43	57
Potato	80	50.0	post-HS	31	33	126	38	62
Other[x]	100	48.5	post-HS	39	33	17	64	36
Average	94	51	post-HS	44	33	46	53	47

[z]Percent of income derived from primary vegetable crop.
[y]Post-HS = some post-high school education
[x]Includes tomatoes, asparagus, peas, cabbage, green beans, garlic, chili peppers, and pumpkins.

Table 3. Number of field operations performed or applied, chemical sprays and IPM use by Utah vegetable growers.

Crop	Field operations: No. performed or applied[z] Primary	Secondary	Chemical sprays: No. performed or applied Weed	Disease	Insect	IPM use[y] (%)
Onions	4.8	8.4	3.4	0.7	5.4	54
Sweet corn	3.6	4.6	1.4	0.1	2.6	48
Melons	4.1	6.6	0.3	0.4	0.2	14
Potato	3.8	5.8	0.6	0.6	1.4	40
Other[x]	3.3	5.5	0.8	0.0	0.8	60
Average	4.0	6.3	1.8	0.4	3.0	48

[z]Number of trips in field for all tillage events and to spray all chemicals.
[y]Percentage using specific practices including scouting, appropriate chemical use, and natural predators.
[x]Includes tomatoes, asparagus, peas, cabbage, green beans, garlic, chili peppers, and pumpkins.

nutrient composition of these sources when determining their fertilizer needs. Cover crops are used by 25% of the growers and almost all growers (94%) used crop rotations. Soil and tissue testing and field nutrient trials, a part of modern nutrient management, were not used by most Utah vegetable producers (data not shown). In addition, many growers did not understand the relationship between water and fertilizer use and few could tell how much water they needed to apply to grow their crop. Extension efforts focusing on these issues are presently being implemented.

If growers are to alter their present production practices, alternative information needs to be available to them about sustainable practices. Farmers were asked who they turn to for advice when they need help or information on vegetables. In general, farmers tend to use other farmers for information (Table 5). While few growers use consultants, larger farmers consult them more frequently than small farmers. However, farmers who earn >25% of their income from vegetables use extension personnel (county agent or specialists) more than growers who earn <25% of their income (small farmers) from vegetables. Those growers earning <25% of their income from vegetables farm an average 1 to 9 acres and hold off-farm jobs (data not shown). Since less time is spent farming, contacts with extension would be limited.

A perceptual index measuring farmer attitude toward adoption and use of sustainable practices was developed from questions about common agricultural practices (data not shown). Although the perceptual index did not serve as a proxy for a more detailed evaluation of farming practices, it helped identify farmers who may be candidates for collaborative research or extension projects. By asking attitudinal questions, the growers interest in and receptivity to changing from more traditional to more sustainable farming practices was measured. With this information, individuals were identified as above average use of sustainable practices or having appreciation for the value of sustainable practices. However, Roling (1988) and Flora (1992) stated that decisions to adopt more sustainable practices must be compatible with the existing production system, maximize the choices for the farm family, be financially profitable, and overcome the resistance to change that farmers possess. An earlier study by Drost et al. (1996) reported that Utah's farmers are resistant to change unless there are perceived financial savings or more information is provided. With our perceptual index, we now also have a reference point from which to measure the effectiveness of future research and extension efforts and a way to measure change or resistance to sustainable practices by Utah's vegetable growers.

The farming index (Table 1) was used to assess whether growers were using sustainable practices. Farmers with high scores were actively practicing IPM, attempting to reduce nutrient inputs, or were better soil managers. While not directly measured, past farming experience may dictate which practices are used on the farm. We have shown previously that older farmers tend to be less likely to adopt new or alternative production practices regardless of the benefits (Drost et al., 1996). Most farmers in that study believed that their farms were already sustainable and many felt that more time, money, and information was needed for additional change to occur. Flora (1992) states that farms and farmers are moving toward sustainability and that, by changing farm practices, one is not suddenly sustainable. Use of the farming index and understanding the individuals farm practices now allows us to

Table 4. Percent use of nutrient sources, cover crops and rotations and percent who know total water applied of Utah vegetable growers for five crops.

Crop	Nutrient source[z]: Fertilizer Synthetic	Organic	Credit organic source	Cover crops	Rotations	Know water use[y]
Onions	100	71	17	21	100	21
Sweet corn	100	87	22	30	87	26
Melons	100	86	48	29	86	29
Potato	100	60	33	20	100	40
Other[x]	100	100	30	30	100	30
Average	100	81	25	26	94	26

[z]Percent use of synthetic or organic nutrient sources and percentage who credit organic sources when calculating fertilizer needs.
[y]Percent of growers who know the acre-feet of water applied to their fields.
[x]Includes tomatoes, asparagus, peas, cabbage, green beans, garlic, chili peppers, and pumpkins.

Table 5. Percent of Utah vegetable growers who use three information sources for two income level.

Income from vegetable production (%)	Information source: Farmers	Consultants	Extension[z]
≤25	48	9	48
>25	49	17	57
Significance	NS	*	*

[z]Includes Cooperative Extension agents and specialists.
NS,*Nonsignificant or significant by t test ($P \leq 0.05$).

monitor the dynamic process of growers moving toward sustainable vegetable production.

The lack of correlation between the farming and perceptual indexes indicated that there was little relationship between a vegetable farmers practice (field operations, nutrient management, and IPM) and how they perceive sustainable agricultural practices (Table 6). However, IPM use and field operations were correlated ($r = 0.49, p = 0.01$), which shows that those using IPM techniques on their farms also tend to till less. Age was also correlated with field operations ($r = 0.27, p = 0.05$), indicating that older more experienced farmers used fewer tillage operations than younger farmers. Age was negatively correlated with income ($r = -0.37$, $p = 0.01$). However, older farmers, having farmed longer, tend to have more diverse farms (less of their income gained from vegetables) than younger farmers.

Utah's vegetable growers perception and index of use of sustainable (field operations, nutrient management, or IPM) practices were not correlated ($r = 0.01$, n = 69). Drost et al. (1996) noted that, although most Utah farmers consider themselves sustainable, few practice sustainable agriculture. However, as noted earlier, vegetable farming operations (field operations, chemical use) vary greatly from crop to crop, which may explain why there was little correlation between farmer perception and practice. Others have noted that categorizing farmers into homogeneous groups is necessary if diffusion of new innovations and practices is to occur (Roling, 1988; van den Ban and Hawkins, 1988). Since cultural practices vary from crop to crop, additional evaluation of farms by commodity is warranted.

The perceptual and farming indices identify individuals that may be good candidates for cooperative efforts in research and education (data not shown). These are farmers who have a high perception and high index of use. These individuals understand what it takes to be sustainable and attempt to put that information into practice. At the same time, the indices also identify farmers who are resistant to change or, due to other constraints, fail to practice sustainable farming systems (low perceptual and farming index values). To implement new practices successfully, new education and research approaches are needed (Flora, 1992; King, et al., 1989; Roberts and Lighthall, 1993). While research and extension will continue to work with the large progressive farmer, our indices now allow us to identify small farmers who are innovators or in need of extra help. Regardless of the farm size, if farmers are to accept and adopt more sustainable practices, they need to be active participants in the research (Odum, 1989; Roberts and Lighthall, 1993) and involved in the transfer of that information (Francis and Hildebrand, 1989; Keeney, 1990; King et al., 1989). The partnership between extension and the farmer needs strengthening since pressures on farmers to adopt more sustainable practices are increasing (Auburn, 1994).

Continuing to work primarily with large progressive farmers with the expectation that diffusion will result in adoption of best practices by all farmers fails to meet the needs of Utah's vegetable farmers. Since commodities vary in their production practices and needs, a more focused approach on homogeneous subgroups of farmers is needed if technology and information transfer are to succeed. Although the perceptual index could not substitute for a more detailed farm evaluation, together with the farming index it was a good way to identify farmers practicing sustainable agriculture and those needing to learn these practices. Both measures will continue to be used with vegetable farmers in Utah as we begin to identify and address research priorities for some of the different vegetable commodities.

Table 6. Correlation matrix for Utah vegetable growers' perception of sustainable practices and actual tillage practices, nutrient management, integrated pest management (IPM) use, years farming, income generated from vegetables, education level, farmer age, and acres grown.

	Perception	Index of use: Tillage	Nutrient	IPM	Years	Income	Education	Age
Tillage practice	–0.11							
Nutrient management	0.18	–0.15						
IPM								
Use	–0.16	0.49**	–0.16					
Years farming	–0.05	0.15	–0.19	0.00				
Vegetable income	–0.03	0.04	0.16	0.16	–0.19			
Education level	0.14	0.03	0.10	0.01	–0.27*	–0.15		
Farmer								
Age	0.05	0.27*	–0.13	–0.01	0.65**	–0.37**	–0.21	
Acres grown	–0.15	–0.07	0.00	0.12	0.05	0.08	0.14	0.09

*,**Significant at $P \leq 0.05$ or 0.01, respectively.

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