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Evaluation of a 3 year intervention to increase adoption of safer nursery crop production practices

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ABSTRACT

Background: We conducted a 3 year intervention to increase awareness and adoption of eight more profitable nursery crop production practices that reduced certain traumatic and musculoskeletal injury hazards.

Methods: We disseminated information to nursery managers across seven states using information channels they were known to rely on (e.g. trade publications, public events, university Extension, other managers). We evaluated rolling, independent, probability samples ($n = 1200$) with mail questionnaires before the intervention and after each of 3 intervention years. We also evaluated samples ($n = 250$) from a comparison group of New Zealand nursery managers.

Results: The intervention was associated with increased awareness of four of the eight practices among US managers after year 3 compared to their baseline: zippers (20 vs. 32%, $p \leq 0.000$), stools (11 vs. 22%, $p \leq 0.001$), pruners (29 vs. 40%, $p \leq 0.014$), and tarps (24 vs. 33%, $p \leq 0.009$). There were no changes in adoption. New Zealand manager awareness was increased for hoes after year 2 compared to their baseline (35 vs. 52%, $p \leq 0.010$).

Conclusions: A modest, regionwide information dissemination intervention was associated with increased awareness, but not adoption.

1. Introduction

In 2002, seven US Great Lakes states (Wisconsin (WI), Minnesota (MN), Iowa (IA), Michigan (MI), Illinois (IL), Indiana (IN), Ohio (OH)) accounted for about 18% (4467 operations) of all US firms producing nursery stock (USDA, 2002). Workers involved in field-grown nursery crop production are exposed to high risks of traumatic and musculoskeletal injury (Howard et al., 2005; Giguere, 2003; Howard, 2000; Duraj et al., 1998; Parish, 1998; Methner and Miles, 1997; Trites et al., 1993; Carrasco et al., 1991; Wallersteiner, 1987; Stinson et al., 1971). A joint USDA/NIOSH population-based mail survey estimated that US nursery operations in 1995 experienced a rate of 7.3 lost time injuries per 100 full time equivalent (FTE) workers (i.e. per 200,000 h worked) (Myers, 2001). This rate exceeded the average for all farms (6.8) and was third highest among all eight farm types, after cash grain farms and beef, hogs, and sheep farms. The national rate for non-fatal injury and illness in the 2004 US workforce aged greater than 15 years was 2.5 per 100 FTE workers (based on hospital emergency room records) (Derk et al., 2007). A study based on injury records determined that California plant nurseries suffered musculoskeletal disorders at an annual rate of 4.0 per 100 FTE workers (compared to the state's all industry average of 0.3) (Janowitz et al., 1998; Cal OSHA, 1999).

Some operations that produce field-grown nursery crops have developed or adopted specific production practices that simultaneously improve profitability and reduce physical risk factors for work-related injuries and musculoskeletal disorders (e.g. Newenhouse et al., 2004 a,b,c; 2005 a,b,c,d; Chapman et al., 2005). Previous research has established that better information flow to individual firm managers can increase the speed with which more profitable practices are adopted in agriculture and other industries (Rogers, 2003; Wejnert, 2002; Fliegel and Korsching, 2001; Feder and Umali, 1993). We investigated whether an intervention that improved information flow to US nursery managers could increase their awareness and adoption of eight more profitable production practices that reduced exposures to musculoskeletal and traumatic injury hazards.

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2. Methods

2.1. Participants

2.1.1. Treatment group

US Department of Agriculture lists of all operations producing field-grown nursery crops were not available to us; we created our own list. The sampling frame we used for the US nursery operations contained 6790 operation names and addresses that came from a combination of state nursery inspector's lists and nursery grower association lists for Wisconsin, Minnesota, Iowa, Michigan, Ohio, Indiana and Illinois. We cleaned the lists by deleting sales outlets, such as hardware stores and landscape businesses, that strictly installed or maintained plants but did not grow them, along with garden clubs, park districts, and golf courses. In previous work, we had used a sample of nursery managers as a comparison group for studies on practices used by berry growers and vegetable growers (Chapman et al., 2008, 2004). We deleted those operations from our database since they had been exposed (via our mail questionnaires) to some of the practices we promoted in this study. We mailed questionnaires to rolling, independent probability samples (i.e. a different group each year) of managers in the off-season (January–March) of the baseline year and after intervention years 1, 2, and 3.

2.1.2. Comparison group

New Zealand nurseries were an appropriate comparison group because their average operation size was similar, they used similar production practices (and so could benefit from the same safer, more efficient practices), and they were unlikely to be exposed to the public events and resource people in the US that we were using to deliver the intervention (although they may have been exposed to our intervention's print media grower publications or Internet components which were available internationally). We used the New Zealand Nursery Register, a list maintained by trade associations that included over 1000 nursery operations. We mailed questionnaires to rolling independent probability samples of 250 New Zealand managers in the off-season (June–August) of the baseline year and after intervention years 1 and 2 (but not after year 3).

2.2. Intervention theoretical basis

We based our approach on a widely used theoretical model (Rogers, 2003) and on other research about how individuals adopt agricultural technologies (Fliegel and Korsching, 2001). The model postulates that farm managers proceed through various stages in a sequential fashion from: (1) awareness; (2) information gathering and consideration; to (3) adoption of the innovation and that informational communications often move through multiple information channels and human actors before they reach the manager (Rogers, 2003). Our intervention's materials and methods were designed accordingly. For example, we provided nursery manager populations with short articles about the practices. We also developed more detailed poster displays and slide presentations about the eight practices for university Extension agents and others to use at public events where they shared information with managers.

2.3. Intervention components

We based our intervention's outreach on results from a questionnaire we administered to 212 US nursery managers in the baseline year where we asked "What sources did you use last year to learn about new equipment or procedures?" They reported using print materials (such as grower newsletters and magazines and agricultural newspapers) (71%), other nursery managers (69%), equipment dealers or farm suppliers (38%), university Extension agents (27%), public events such as grower meetings and conferences (18%), the Internet (9%) and radio and TV (4%) (Chapman et al., 2005). Our intervention promoted the eight practices using all these information channels as often as possible and we asked about each in all our mail evaluation questionnaires.

2.3.1. Other growers

We facilitated grower to grower exchanges by recruiting pilot nursery managers who were already using the practices to cooperate with our intervention. We recruited a dozen pilot nurseries, eight in WI and two each in OH and MN. We encouraged nursery managers and agricultural journalists who were interested in particular production practices to contact and visit the pilot nurseries.

2.3.2. Print mass media

Agricultural journalists were enlisted at the eleven trade publications we judged to be those most regularly read by US nursery managers in the seven states for information about new production methods (i.e. four regional or national producer magazines and the nursery organization newsletters in each state). With phone contacts, visits and mailings, we helped to equip journalists at these publications to write their own articles with press packets (e.g. a press release, one-page tip sheets on each work practice, photos, story ideas, and lists of potential telephone interview contacts). We kept track of all articles that appeared in producer publications featuring the eight production practices we were promoting. We used standard methods to determine column inches of coverage specific to our production practices for each article that appeared during the baseline and the 3 intervention years (Treno et al., 1996).

2.3.3. Public events

Our staff attended as many regional and national nursery conferences as possible each year. We also enlisted resource people (e.g. university Extension, grower organization staff) and other growers already using the production practices to attend local and regional grower meetings and conferences where they set up and staffed exhibits, delivered presentations, and distributed our one-page, two-sided tip sheets about each practice (or a summary handout describing all of the practices). Our materials were available at least one growers' meeting or conference in each state in the first intervention year, and at least three by the third year. We also assisted some of the nursery managers who had already adopted the practices with their travel expenses so more could attend conferences and workshops and serve as presenters and exhibitors at these public events.

2.3.4. Resource people

We sent mailings of the one-page tip sheets about each practice biannually to university Extension horticulture agents, staff at nursery organizations in the seven states, and to other advisors for them to distribute during their farm visits and group programs. We developed relationships with resource people and nursery managers through face to face contact at regional conferences and trade shows. We also made phone calls to assess their efforts and to learn about how to improve our efforts in the next year.

2.3.5. Radio and TV

We recorded four short radio interviews about the work practices that were aired on farm radio shows in Wisconsin. Four other interviews were aired regionwide (Newenhouse, 2003).

A television segment featuring growers using our tools and staff discussing the practices was aired on the nationally-syndicated "US Farm Report: Town and Country Living" and AgDay TV.

2.3.6. Internet

We maintained a website where non-copyrighted materials, photos, and presentations about each practice were freely available (http://bse.wisc.edu/hfhp/). We announced the website via postcards that we sent to resource people and journalists and included our website listing on business cards, letterhead, and all our printed materials. Website activity data was collected about entry page, location and date of visitor and search keywords used.

2.4. Production practices

In the year before the intervention began, we recruited a half dozen nursery managers and another group of nursery resource people for two separate focus groups to explore the best practices to promote and the best ways to promote them. We chose the practices that we promoted during the intervention according to a combination of different criteria, each of which carried a certain amount of weight in our ranking system. The first criterion was whether the tool would help reduce worker exposures to risk factors for traumatic or musculoskeletal injury. The second criterion was whether the tool was new to the industry and not widely already in use. The next group of criteria included whether a sufficiently large segment of the target population could be interested in using the tool, whether the tool's price would be likely to fall into the range of consideration for a nursery manager, whether it increased work efficiency enough to give it a reasonable payback period, and whether the concept of the tool and its advantages were easy to describe and therefore would be easy to grasp in our outreach materials. Calculations of payback period and work efficiency improvements depended on fluctuating factors such as what type of production method was used, operation size, number of workers, pay rate, system in use for the task under consideration, availability of equipment that would work in conjunction with the tool, and availability of resources. We relied on our own judgment in determining the payback period and labor efficiency changes for each practice based on our knowledge of the industry, and on visits to nurseries and discussions with growers, nursery advisors, and equipment manufacturers. The eight production practices that the intervention promoted are described in Fig. 1.

2.5. Questionnaire and procedure

We developed a mail questionnaire that required about 20 min to complete that was based on standardized recommendations (Dillman, 1999; Spielholz et al., 1999; Kuorinka et al., 1987). We were interested in what percentage of managers reported they were aware of each practice before and after our intervention. Because the process of filling out the questionnaire also made growers aware of the practices, we decided to use a rolling sample cohort design, mailing surveys to a different sample of operation managers each year from the US and NZ sampling frames (Babbie, 1990).

The cover page requested that the questionnaire be filled out by the operator or the person who made most of the management decisions about how the nursery ran. We excluded operations that produced less than \$500 worth of nursery crops last year. As an incentive to encourage responses, the accompanying cover letters stated that individuals who completed and returned the questionnaire would receive ten first class US (or New Zealand) postage stamps. The cover letters also emphasized the social utility of the survey, the importance of each respondent completing the survey, and the privacy protections for returned questionnaires. We also included three first class stamps as an incentive in the initial mailing. A series of follow-up mailings were made to non-respondents, including a reminder postcard after 1–2 weeks, a repeat mailing of the questionnaire and cover letter 4 weeks after the initial mailing, and a second reminder postcard 6 weeks after the initial mailing. The protocol was approved by the University of Wisconsin–Madison College of Agricultural and Life Sciences' human subjects committee. The questionnaire is available from the authors.

2.6. Research questions and data analysis

Reasonably complete questionnaires were coded and entered into a database. All questionnaires were manually checked to verify the accuracy of data entry. Pearson's Chi Square test was used to compare percentages (SPSS, 1996). For a test of proportions, (e.g. percent values of adoption and awareness) the sample size required to capture an effect size difference of 10% at baseline compared to 20% after the intervention as significant at $p \leq 0.05$ with 90% power in a one-sided test (e.g. Pearson's Chi Square) is an "n" of 217 for each group (Lwanga and Lemeshow, 1991, p. 36). This number is well within or close to our anticipated numbers of completed questionnaires (US treatment $n = 429$, NZ control $n = 211$). No adjustments were made for multiple statistical comparisons. Our evaluation tested three research questions in order of priority:

2.6.1. Did managers report more awareness or adoption?

US baseline data were compared to data collected after intervention year 3 with a Chi Square test of proportions (and New Zealand baseline data were compared to year 2) for each of the eight production practices.

2.6.2. Why did aware managers not adopt?

Data from all years from managers who said they were aware of a practice were combined for the US and compared to the New Zealand data with a Chi Square test of proportions.

2.6.3. Did managers report getting more information?

US baseline data were compared to data collected after intervention year 3 with a Chi Square test of proportions (and New Zealand baseline were compared to year 2).

3. Results

3.1. Questionnaire responses, sample demographics and intervention process measures

Overall, the return rates for the questionnaires ranged from 49 to 57% for the US growers and were from 64 to 76% for the New Zealand growers (see Table 1). Each year, about one-half (45–58%) of the returned US questionnaires were designated ineligible because they were returned by individuals who reported that they had never produced field-grown nursery crops, no longer grew them, no longer were operation managers, or failed to grow a commercial crop that year ($\leq$\$500 worth of nursery crops). These questionnaires were not retained for further analysis. The return rates were higher (64–76%) and the proportion of ineligible responses from returned New Zealand questionnaires was smaller (27–45%). Analyses of the eligible, reasonably complete questionnaires showed that nearly all of the demographic variables were similar across years, aside from anticipated increases over time in manager age and years in nursery.

For each of the eight work practices, the number of articles and their total column inches, as they appeared in nursery trade

Fig. 1. Photos and descriptions of the eight production practices promoted by the intervention. (a) *Electronic Pruners*. Electronic pruners are considerably more efficient than manual pruners when cutting heavy stock and may be able to cut pruning time by as much as 20%. Because electric power makes the cuts, they also reduce strain and fatigue on the arms, wrists, hands, and fingers so employees can more easily work for a longer period of time, even on thicker wood. Typical electronic pruners cost $1,500-1,800 and can pay back their cost in labor savings on an operation in three years where 150 hours of pruning work is done each year (or in twelve years where 40 hours of pruning is done annually) (Chapman et al., 2005) (b) *Long-handled diamond hoes*. These hoes are sharp on four sides of the diamond-shaped blade and have a six foot long handle with a "T" on the end. Many berry growers use hoeing crews to remove at least a portion of their weeds, because not all weeds are killed by herbicides or tractor-pulled cultivators. Workers can stand upright instead of leaning over and they can glide the hoe back and forth (with the motions used in running a vacuum cleaner over carpet) instead of using the bent-forward, chopping motion commonly used with other hoes. Workers can change their posture often, for example pushing or pulling, and use the hoe with one hand or the other (or both) on the "T" handle. The long-handled hoe requires less effort to use compared to other hoes and the work is done faster. The hoes are inexpensive at around $40 each (Newenhouse et al., 2004a). (c) *One person hitches*. This practice saves time when hitching compared to climbing on and off the tractor and compared to having a second person assist with the hitching. Unhitching is also quicker. The hitch also reduces the risk of serious injury possible when heavy equipment crushes fingers or when workers become pinned between tractor and wagon. Workers sometimes slip and fall while hitching or unhitching, and then risk being run over. A one person hitch system for a single tractor and three wagons costs $800 and would payback its cost in labor savings after 3200 hitch cycles (Newenhouse et al., 2004b). (d) *Field stools*. The stools allow employees to avoid the repeated stooping or squatting required to tend or pick crops at or above the soil level. The stool is worn like a belt, does not interfere with movements, allows workers to move instantly from standing to sitting and back, and is inexpensive (< $25) (Newenhouse et al., 2004c; Matilla et al., 2000). (e) *Tree guard zippers*. For operations that use 3" or 4" diameter corrugated plastic tree guards to protect trees from deer and other types of trunk damage, tree guard zippers can make it easier to install and remove these protective sleeves. They save time, prevent scarring and scratching of the trunks, and can reduce the hand pain and fatigue that comes with repetitive gripping and spreading the edges of the guards. In our field trials, workers were 37% faster at installing and 27% faster at removing tree guards with a zipper than they were without one. A zipper is inexpensive at $50 and can pay for itself in labor savings quickly (Newenhouse et al., 2005a). (f) *Container stabilization systems*. Each time a container blows over, workers have to spend time tipping the plants back up. Container stabilization systems eliminate the need to right tipped containers, thereby saving these labor costs and they also save money by preventing the spills that waste fertilizer and add chemicals to runoff. Container stabilization systems can reduce the repeated stooping, bending, gripping and awkward lifting postures. Different systems vary in cost from stakes at $28 per hundred, connectors at $90 per hundred, wire basket stabilizers at $600 per hundred, or plastic inserts at $35 per hundred to stabilize two gallon containers. Payback period depends on the number of hours per year an operation currently devotes to righting containers (Newenhouse et al., 2005b). (g) *No-climb truck tarping systems*. When workers load a wagon or truck with plants they need to pull a tarp over the load. Typically workers climb the load or are carried aloft by a skid steer loader. No-climb truck tarping systems are ways to tarp a load while standing on the ground or sitting in a tractor seat. They come in a variety of mechanisms to fit different scale operations and budgets and prevent risk factors such as falls and sprains. Tarping is done faster and with less damage to the crop. Truck tarping systems can be obtained for as little as $60 or as much as $2000. The payback period for any system will depend on this initial cost and how many tarping cycles are accomplished per year (Newenhouse et al., 2005c). (h) *Pot-filling machines*. Many operations fill pots by hand pouring soil from a scoop. Pot-filling machines speed and ease this work. With a pot filling machine, workers do not need to lift the soil by hand, shortening the time spent transplanting. The machines also alleviate wear and tear on muscles and joints in the fingers, hands, wrists, arms, shoulders and neck from hours of scooping and lifting soil into pots. A typical machine can cost between $6000 to $16,000. The $16,000 machine will pay for itself in labor savings after filling 88,000 pots (Newenhouse et al., 2005d)

publications, are listed in Table 2. Over the 3 years that the intervention promoted them, nine articles appeared about field stools, amounting to 109.8 total column inches of coverage. There were seven articles about the one person hitch (75.5 column inches) and three about the long-handled hoe (24 column inches). The other five work practices were promoted for 2 years. Of them, the tree guard zipper received the most coverage (four articles totaling 59.8 column inches), followed by the electronic pruners (three articles totaling 51.8 column inches). Table 2 also shows the number of public events where we distributed information about the eight practices to US managers. In the first intervention year, we promoted the hoe, hitch and field stool at 10 public events. In the second and third intervention years, we promoted all eight practices at 11 and then 14 public events.

3.2. Did managers report more awareness and adoption?

3.2.1. US

After the 3 year intervention, managers reported greater awareness, compared to baseline, for four of the eight practices: electronic pruners (29 vs. 40%, $p \leq 0.014$), field stools (11 vs. 22%, $p \leq 0.001$), tree guard zippers (20 vs. 32%, $p \leq 0.000$), and tarp draping systems (24 vs. 33%, $p \leq 0.009$) but there were no changes in adoption for any of the practices (see Table 3). In post-hoc analyses, we explored whether operation size had a consistent effect on manager awareness of the eight practices. We stratified data from US managers for all 3 years after the intervention began into a low (<2 hectares/5 acres) and a high (>2 hectares/5 acres) operation size group. There were no differences in awareness for field stools or container stabilization systems. Smaller operations

Table 1
Characteristics of the nursery operation samples.

Characteristic	Group	Year 0	Year 1	Year 2	Year 3	p[a]
Questionnaires mailed	US	1200	1194	1199	1199	
	NZ	250	250	250	–	
Number returned (% of mailed)	US	684 (57%)	633 (53%)	612 (51%)	582 (49%)	
	NZ	170 (68%)	159 (64%)	191 (76%)	–	
Number eligible (% of returns)	US	375 (55%)	322 (51%)	332 (55%)	247 (42%)	
	NZ	124 (73%)	108 (68%)	105 (55%)	–	
Manager age	US	52 ± 11	51 ± 13	53 ± 11	55 ± 11	0.000
	NZ	50 ± 10	51 ± 10	51 ± 11	–	0.635
Manager education (1–9)[b]	US	5.85 ± 2.00	5.85 ± 1.82	5.85 ± 1.88	6.14 ± 1.96 0.083	
	NZ	5.11 ± 1.95	5.06 ± 1.99	4.90 ± 1.80	–	0.416
Manager gender (% male)	US	78%	81%	84%	83%	0.175
	NZ	79%	72%	73%	–	0.001
Manager years in nursery	US	19 ± 12	18 ± 14	22 ± 13	21 ± 11	0.004
	NZ	19 ± 11	19 ± 12	22 ± 12	–	
Median hectares (acres)	US	1.6 (4.0)	1.6 (4.0)	2.0 (5.0)	2.4 (6.0)	
	NZ	1.2 (3.0)	1.5 (3.7)	1.5 (3.8)		
Gross sales last year[c]	US	3.84 ± 2.43	3.91 ± 2.48	4.19 ± 5.82	4.15 ± 2.42	0.145
	NZ	4.62 ± 2.02	5.31 ± 7.87	4.85 ± 2.2	–	0.416
Anyone injured last year (% yes)[d]	US	16(4%)	12 (4%)	14 (4%)	6 (3%)	0.374
	NZ	15 (12%)	13 (12%)	7 (7%)	–	0.186
Injured w/medical last year[e]	US	27 (7%)	15 (5%)	21 (7%)	15 (7%)	0.869
	NZ	14 (12%)	13 (12%)	8 (8%)	–	0.499

[a] p values for US line are US year 0 vs. US year 3. p values for NZ line are for NZ year 0 vs. NZ year 2. Calculations used Chi Square for percent and Student's t-test for numerical values with $^{*}p \le 0.05$. $^{**}p \le 0.01$. $^{***}p \le 0.001$.
[b] Education is 1–9 scale where, for US: 1 = grade school, 2 = some high school, 3 = high school grad, 4 = high school plus vo/tech, 5 = some college, 6 = 2 year associate degree, 7 = 4 year college degree, 8 = some graduate school, 9 = graduate degree and for New Zealand: New Zealand: 1 = primary school, 2 = some secondary school, 3 = school certificate (11–12 years), 4 = university entrance (13 years), 5 = some tertiary ed (Tech Inst./Univ), 6 = University diploma (<2 year) or Technical Institute Degree, 7 = University degree (BS/B), 8 = some post-graduate study, 9 = post-graduate degree (MSc/PhD).
[c] Gross sales is 1–8 scale where 1 = <$5,000, 2 = $5–15k, 3 = $15–25k, 4 = $25–50k, 5 = $50–100k, 6 = $100–200k, 7 = $200–400k, 8 = >$400k.
[d] Anyone injured refers to the number of injuries reported that led to stopping work.
[e] Injured with medical refers to the number of injuries reported that led to seeking medical attention.

showed greater manager awareness for two practices: hoes (51 vs. 39%, $p \le 0.001$) and pot filling machines (58 vs. 48%, $p \le 0.003$). Large operations had greater manager awareness for four practices: pruners (43 vs. 32%, $p \le 0.001$), hitches (34 vs. 22%, $p \le 0.001$), zippers (33 vs. 16%, $p \le 0.000$) and tarp draping systems (32 vs. 18%, $p \le 0.000$).

3.2.2. New Zealand

After the second intervention year, New Zealand managers reported greater awareness, compared to their baseline, for the field stool (35 vs. 52%, $p \le 0.010$). There were no changes in adoption for any of the practices.

3.2.3. US vs. New Zealand

After the second intervention year, US managers were more likely to be aware of hitches (US 33 vs. NZ 10%, $p \le 0.000$), tree guard zippers (US 31 vs. NZ 3%, $p \le 0.000$), and tarp draping systems (US 26 vs. NZ 3%, $p \le 0.000$). On the other hand, New Zealand managers were more likely to be aware of pruners (US 36 vs. NZ 54%, $p \le 0.004$), container systems (US 33 vs. NZ 50%, $p \le 0.002$), and pot filling machines (US 50 vs. NZ 73%, $p \le 0.000$). New Zealand managers also appeared to lead in adoption after intervention year 2 for hoes (US 19 vs. NZ 33%, $p \le 0.000$).

3.3. Why did aware managers not adopt?

3.3.1. US

Each year, managers were asked to check as many as 16 possible reasons why they had not adopted each of the eight practices (Table 4). When only those managers who reported that they were already aware of the practice were included from all available years (baseline through year 3), they cited most often "nursery too small" (10–52% range over eight practices) followed by "no use for my crops" (15–33%), "too expensive" (3–42%), "lack of information" (10–24%), and "never seen it used" (4–15%).

3.3.2. New Zealand

In data from all years, managers most often cited "no use for my crops" (21–55%), followed by "nursery too small" (6–48%) and "too expensive" (4–27%).

Table 2
US Midwest print and event information dissemination about the eight practices.

Practice and variable	Year 1	Year 2	Year 3	Total
Electronic pruners				
Number of articles	–	2	1	3
Article total column inches	–	17.5	34.5	51.8
Number of public events	–	11	14	25
Diamond hoes				
Number of articles	0	3	0	3
Article total column inches	–	24	–	24
Number of public events	10	11	14	35
One person hitches				
Number of articles	2	4	1	7
Article total column inches	17.5	43	15	75.5
Number of public events	10	11	14	35
Field stools				
Number of articles	2	4	3	9
Article total column inches	5	60	44.75	109.8
Number of public events	10	11	14	35
Tree guard zippers				
Number of articles	–	2	2	4
Article total column inches	–	27	32.75	59.8
Number of public events	–	11	14	25
Container stabilization systems				
Number of articles	–	1	1	2
Article total column inches	–	21	43	64
Number of public events	–	11	14	25
Tarp draping systems				
Number of articles	–	0	2	2
Article total column inches	–	–	59.5	59.5
Number of public events	–	11	14	25
Pot filling machines				
Number of articles	–	0	0	0
Article total column inches	–	–	–	0
Number of public events	–	11	14	35

Table 3
Nursery manager reports of awareness and adoption for the eight practices.

Practice	Group	Year 0	Year 1	Year 2	Year 3	p[a]
Awareness[b]						
Electronic pruners	US	–	94 (29%)	117 (36%)	92 (40%)	0.014
	NZ	–	45 (41%)	54 (54%)	–	0.130
Diamond hoes	US	145 (39%)	134 (42%)	140 (44%)	89 (43%)	0.394
	NZ	42 (35%)	49 (46%)	54 (52%)	–	0.010
One person hitches	US	101 (28%)	88 (28%)	116 (33%)	61 (26%)	0.850
	NZ	9 (7%)	20 (19%)	10 (10%)	–	0.632
Field stools	US	43 (11%)	55 (17%)	47 (15%)	53 (22%)	0.001
	NZ	5 (5%)	5 (5%)	9 (9%)	–	0.168
Tree guard zippers	US	–	60 (20%)	101 (31%)	77 (32%)	0.000
	NZ	–	4 (4%)	3 (3%)	–	1.000
Container stabilization	US	–	116 (37%)	106 (33%)	93 (39%)	0.596
	NZ	–	40 (37%)	50 (50%)	–	0.722
Tarp draping systems	US	–	75 (23%)	83 (26%)	79 (33%)	0.009
	NZ	–	5 (5%)	3 (3%)	–	0.722
Pot filling machines	US	–	162 (51%)	159 (50%)	119 (50%)	0.797
	NZ	–	83 (77%)	73 (73%)	–	0.425
Adoption						
Electronic pruners	US	–	4 (1%)	6 (2%)	4 (2%)	0.867
	NZ	–	2 (2%)	5 (5%)	–	0.425
Diamond hoes	US	74 (20%)	48 (15%)	59 (19%)	49 (21%)	0.450
	NZ	25 (21%)	27 (25%)	34 (33%)	–	0.837
One person hitches	US	14 (4%)	3 (1%)	10 (3%)	10 (4%)	0.928
	NZ	0 (0%)	5 (5%)	0 (0%)	–	1.000
Field stools	US	4 (1%)	1 (0%)	0 (0%)	2 (1%)	0.437
	NZ	0 (0%)	2 (2%)	1 (1%)	–	1.000
Tree guard zippers	US	–	5 (2%)	11 (3%)	12 (5%)	0.273
	NZ	–	1 (1%)	0 (0%)	–	1.000
Container stabilization	US	–	31 (10%)	26 (8%)	30 (13%)	0.492
	NZ	–	13 (12%)	14 (14%)	–	0.828
Tarp draping systems	US	–	11 (3%)	14 (4%)	15 (6%)	0.754
	NZ	–	0 (0%)	1 (1%)	–	0.082
Pot filling machines	US	–	20 (6%)	21 (7%)	15 (6%)	0.230
	NZ	–	18 (17%)	12 (12%)	–	0.425

[a] p values for US line are US year 0 (if available, otherwise year 1) vs. year 3. p values for the NZ line are NZ year 0 (if available, otherwise year 1) vs. year 2.
[b] Awareness numbers and percents are managers who report being aware plus managers who report adoption because the questionnaire allowed only either response, not both.

3.3.3. US vs. New Zealand

Across all years, New Zealand manager reports exceeded US managers on “no use for my crops” for four of the eight practices: pruner (US 15 vs. NZ 42%, $p \le 0.001$), hoe (US 33 vs. NZ 55%, $p \le 0.01$), hitch (US 22 vs. NZ 32%, $p \le 0.05$), and container systems (US 24 vs. NZ 26%, $p \le 0.01$).

3.4. Did managers report getting more information?

Compared to their baseline, after the third year of the intervention there were no reports of more US managers of getting information from any of the eight information channels about any of the eight practices (Table 2). In fact, significantly fewer US managers reported getting information after the intervention about four practices: long-handled hoes from print media (57 vs. 37%, $p \le 0.002$) and public events (16 vs. 5%, $p \le 0.013$), tarp draping systems from another grower (56 vs. 39%, $p \le 0.048$), pot filling machines from another grower (55 vs. 41%, $p \le 0.020$), and container stabilization systems from websites (7 vs. 0%, $p \le 0.01$).

There were no changes for New Zealand managers reporting where they got information from any of the eight information channels about any of the eight practices when baseline data was compared to data collected after the second year.

4. Discussion

4.1. Did managers report more awareness and adoption?

Our results suggest that we succeeded, at least in part. Within the seven US states that our intervention targeted, our evaluation was able to demonstrate an increase in awareness associated with the intervention for four of the eight practices. However, we were unable to show any increases in adoption of any practice by the US manager group.

4.2. Why did aware managers not adopt?

We may have not promoted the practices long enough. We believe this was the most important factor limiting adoption. Previous research has provided considerable evidence that increasing the adoption of new practices among regionwide groups of thousands of operations can require more than 2 or 3 years of an information dissemination intervention, particularly among managers of agricultural operations (Rogers, 2003; Fliegel and Korsching, 2001; Karshenas and Stoneman, 1995). In agriculture’s classic example, the diffusion of improved hybrid seed corn among Iowa farmers, virtually complete adoption by all eligible farmers required more than 20 years (Fliegel and Korsching, 2001). Research on other types of information communication

Table 4
Reports of why they did not adopt from aware-only nursery managers for all years 2004-2007[a,b].

Reason why not adopted	Group	Pruner	Hoe	Hitch	Stool	Zipper	Container	Draping	Pot	Cumulative %[c]
Nursery too small	US	89 (33%)	26 (10%)	73 (25%)	26 (14%)	30 (17%)	64 (32%)	38 (22%)	189 (52%)	205%
	NZ	23 (27%)	3 (6%)	9 (29%)	3 (19%)	1 (17%)	11 (19%)	1 (17%)	55 (48%)	182%
No use for my crops	US	39 (15%)	86 (33%)	65 (22%)	51 (28%)	51 (30%)	48 (24%)	39 (22%)	54 (15%)	189%
	NZ	36 (42%)***	29 (55%)**	10 (32%)*	7 (44%)	3 (50%)	26 (46%)**	3 (50%)	24 (21%)	340%
Too expensive	US	102 (38%)	8 (3%)	66 (22%)	11 (6%)	16 (9%)	42 (21%)	39 (22%)	151 (42%)	163%
	NZ	23 (27%)	2 (4%)	4 (13%)	1 (6%)	1 (17%)	8 (14%)	1 (17%)	29 (25%)**	123%
Lack of information	US	51 (19%)	57 (22%)	71 (24%)	31 (17%)	26 (15%)	38 (19%)	33 (19%)	35 (10%)	145%
	NZ	13 (15%)	4 (8%)*	5 (16%)	3 (19%)	2 (33%)	11 (19%)	0 (0%)	12 (11%)	121%
Never seen it used	US	39 (15%)	38 (15%)	36 (12%)	21 (12%)	20 (12%)	15 (8%)	17 (10%)	13 (4%)	88%
	NZ	7 (8%)	0 (0%)***	5 (16%)	1 (6%)	0 (0%)	8 (14%)	0 (0%)	7 (6%)	50%
Use similar system	US	15 (6%)	35 (13%)	15 (5%)	19 (11%)	24 (14%)	10 (5%)	24 (14%)	9 (3%)	71%
	NZ	6 (7%)	10 (19%)	2 (7%)	2 (13%)	0 (0%)	1 (2%)	1 (17%)	4 (4%)	69%
Poor investment return	US	40 (15%)	5 (2%)	32 (11%)	10 (6%)	8 (5%)	17 (9%)	19 (11%)	51 (14%)	73%
	NZ	5 (7%)*	0 (0%)	3 (10%)	2 (13%)	1 (17%)	5 (9%)	0 (0%)	6 (5%)**	61%

[a] Note: Over the 4 years from baseline in 2004 to the third intervention year in 2007, the number of respondents who reported they had heard of each of a practice and who answered the “if not why not” question item about reasons for not adopting that practice were: pruner (267 US vs. 86 NZ), hoe (262 US vs. 53 NZ), hitch (295 US vs. 31 NZ), stool (180 US vs. 16 NZ), zipper (172 US vs. 6 NZ), container (200 US vs. 57 NZ) draping (174 US vs. 6 NZ), and pot (364 US vs. 114 NZ).
[b] For tests of statistical significance comparing US vs. New Zealand group using Chi Square test where $^{***}p \le 0.001$; $^{**}p \le 0.01$; and $^{*}p \le 0.05$.
[c] Only the top eight reasons (ranked by total cumulative percent across practices) are shown in the table. Not shown are “can’t try it out first” (61 US vs. 50% NZ), “don’t see the point” (59 US vs. 64% NZ), “other” (28 US vs. 52% NZ), “lack of availability” (34 US vs. 39% NZ), “too time consuming” (21 US vs. 32% NZ), “never heard of it” (12 US vs. 22% NZ), “difficult to use” (25 US vs. 6% NZ), “unsafe” (10 US vs. 21% NZ), and “too physically demanding” (14 US vs. 6% NZ).

interventions has noted the relative speed and ease with which relatively widespread improvements in awareness can be accomplished but how rates of adoption typically increase more slowly (Vaughan and Rogers, 2000). On the other hand, in previous work we promoted two similar practices to managers of fresh market vegetable operations and were able to demonstrate a significant increase in adoption of one practice after just 1 year (Chapman et al., 2004).

We may have used information sources that failed to reach many growers. However, as noted earlier, we asked a probability sample of mangers in our baseline questionnaire where they got information about new practices and we based our information dissemination intervention on their responses. Furthermore, less than 25% of aware US managers cited "lack of information" as one of their reasons for not adopting any of the eight practices.

We may have promoted the wrong practices. However, as noted earlier, we used focus groups of field-grown nursery crop managers and their advisors to help select the practices. Furthermore, only a small minority of aware US managers said they did not adopt any of the eight practices because it was "difficult to use" (2–8%), "too physically demanding" (1–6%), "too time consuming" (0–7%), "lack of availability" (2–8%), "can't try it out first" (3–13%), poor investment return (2–15%), or "never seen it used" (4–15%). Less than half cited "too expensive" (3–42%). These reports also help rule out that we simply failed to promote the practices enough to convince managers to adopt. In previous research, agricultural manager failures to adopt apparently advantageous practices have been ascribed to a variety of factors such as the persistence of perceived risk and uncertainty among potential adopters despite improved information flow, unfavorable practice attributes such as poor return on investment, and the lack of sufficient time for information and persuasion to work (Rogers, 2003; Fliegel and Korsching, 2001). Managers of agricultural operations have been shown to be especially risk aversive compared to managers in other industries (Rogers, 2003; Fliegel and Korsching, 2001; Feder and Umali, 1993). However, our practice attributes were mostly highly favorable. The start up costs were generally low (except for pruners and pot filling machines) and payback periods were very short for the diamond hoes, field stools, tree guard zippers, low-end container stabilization systems and low-end tarp draping systems (i.e. $25–$60).

Our intervention's failure to demonstrate increased adoption of any practice could also be attributable, in part, to the nursery industry's structure. Many of the managers who were aware of the practices reported they did not adopt because of "nursery too small" (10–52%) or "no use for my crops" (15–33%). This suggests that we were promoting at least some practices that some managers felt they were unable to use. There were other indications that the field-grown nursery crop industry was different. During our intervention outreach work we learned that the production of field-grown nursery crops in the US is often accomplished by "niche" producers that concentrate on particular crop varieties, specific crop stages of growth, or that provide other very specific products or services. As a result of this intense heterogeneity among field-grown nursery crop operations, there may be no generic set of tools, equipment or other work practices. Only a minority, instead of the majority of producers may need the electronic pruners, tree guard zippers, container stabilization systems, pot-filling machines, or other practices that we promoted in our intervention. Some evidence supporting this idea is provided by our results from the New Zealand growers where, after year 2, a majority indicated that they were aware of pruners, hoes, and pot fillers (i.e. 52–73%) yet only a small minority (12–33%) reported having adopted the devices and 21–55% reported "no use for my crops" for these practices. Perhaps producers of field-grown nursery crops are such a highly compartmentalized group of operations occupying such widely different niches that their industry associations reflect a shared clientele for their products more than shared production practices. As a group, it may be that they don't seek out and use information about new practices or adopt them in the same way as other agricultural producer groups have in our previous research (Chapman et al., 2008, 2004).

4.3. Did managers report getting more information?

We were surprised that US managers did not report getting more information about any of the eight practices after the 3 year intervention. In fact, there were a few decreases in different information channels for four of the eight practices. It is possible that US nursery managers got information from information channels we failed to consider and ask about. However, as noted above, we used focus groups and surveyed a probability sample of 212 managers from across the region prior to the intervention to determine which information channels they used most often to learn about new production practices.

It is also possible that our nursery manager respondents failed to remember getting information about the eight practices from the information channels we used. However, in our previous work with US managers of dairy, berry, and fresh market vegetable operations we found that manager reports of getting more information about a practice after the intervention often coincided with reports of increased practice awareness and adoption (Chapman et al., 2003, 2004, 2008).

It is also possible that nursery managers were less likely and/or less willing than other types of managers to disclose where they had learned about the eight practices we promoted. Perhaps this reticence reflected concerns about inadvertently aiding their competitors in business, concerns about drawing unfavorable attention to their industry's job safety problems, or concerns about some other perceived business risk. Future nursery industry interventions should investigate manager patterns of information use and willingness to report them in greater detail.

4.4. Study limitations and strengths

Our study was not a randomized control trial. The constraints of conducting and evaluating an intervention in a real world agricultural industry sector of thousands of operations with unrestricted information flow precluded random assignment to treatment and control groups or ex ante control over demographic variables. Our study was also unable to provide a true control group because our New Zealand comparison group could access our Internet-based resources and subscribe to US nursery magazines and newsletters. Our study was prospective and longitudinal but not a comprehensive, community-based trial because no comprehensive sampling frame was available to us that could, with confidence, claim to include all US operations that produced field-grown nursery crops. However, we believe that our New Zealand sampling frame provided more comprehensive coverage. Because evidence that associates an intervention with outcomes cannot constitute proof of causation of those outcomes, we acknowledge that secular trends may have contributed to or may entirely explain those significant changes we did find.

Our US nursery operation sampling frame suffered from poor specificity. Because US Department of Agriculture lists were not available to us, we were forced to cobble together our sampling frame from other sources. Our sampling frame for US nursery operations in the seven states ($n = 6790$) exceeded the 4467 firms that the US Department of Agriculture recognized in 2002 as operations producing nursery crops (USDA, 2002). However, our lists lacked specificity, producing eligible responses from only about half of returned questionnaires. The lists we assembled produced high proportions of respondents from operations that did not produce field-grown nursery crops or that did not produce $500 or more worth of these nursery crops per year. Our statistical power was also likely compromised by the small proportion of nursery businesses that could actually benefit by adopting each of the eight practices, a result of the lack of fit between the practices we promoted and the absence of a generic tool or equipment set within this industry.

Also, although we included New Zealand nurseries as a comparison group, we were unable to take full advantage of them in the statistical sense because of our lack of a sample after intervention year 3, their smaller samples sizes ($n = 250$) relative to the samples for US producers ($n = 1200$), and the lack of full comparability on certain variables we would have liked to have seen better controlled (e.g. baseline rates of awareness and adoption of all eight practices).

One strength was our study's emphasis on collecting intervention process measures to determine whether and how well our intervention efforts were reaching the target audience, often a weak point in previous research (Goldenhar and Shulte, 1994). Our study also incorporated a theoretical model, a feature often lacking in other occupational health interventions (Robson et al., 2001; Goldenhar and Shulte, 1994). Another strength was that our intervention was designed to minimize information access costs about the eight practices by relying on the information channels and networks that our evidence suggested nursery managers already used and trusted (Chapman et al., 2005; Lasley et al., 2001). The degree of difficulty associated with acquiring information about new practices constitutes an access cost to managers and can be a barrier to adoption (Mokyr, 2002). Another strength was the regional reputation of the University of Wisconsin among producers of field-grown nursery crops as a national leader in ornamental horticulture.

Further intervention research with field-grown nursery crop producers should continue to promote practices that couple safety and profits and attempt to more carefully investigate manager information use and manager reasons for declining to adopt practices.

5. Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health. None of the authors has any relationships that may pose conflicts of interest.

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