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Adoption of Sustainable Practices to Protect and Conserve Water Resources in Container Nurseries with Greenhouse Facilities

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Abstract

The intensity of fertilizer and pesticide inputs in California's production nursery industry has led to increasing concern about the adoption of sustainable management practices and potential water quality impacts. While a variety of good management practices have been recommended for greenhouses and nurseries, few studies have documented the extent to which growers have adopted these practices. Thirty-eight container nurseries with greenhouse facilities in Ventura County, CA, USA, completed a 142-question survey to evaluate the adoption of good management practices. In addition to this educational interview, many of the surveyed operators then attended at least one educational meeting addressing sustainable management practices, government regulation, and economic implications of adopting good management practices. Good management practices were adopted widely by surveyed nurseries, with overall 'yes' responses to the adoption of good management practices being 65% and 'not applicable' responses being 38%. Smaller nurseries (<4.0 ha) were less likely to have high adoption rates of good management practices, suggesting that particular attention should be paid to the concerns of smaller nurseries in planning education, outreach, and research activities. The re-survey within two years found significant ($p<0.05$) increases in the number of 'yes' responses overall and in eight out of nine question categories. Significantly more ($p<0.05$) positive responses were recorded for 20 specific practices, including some in integrated pest management, runoff management and container media management categories. These results suggest that nurseries are amenable to the adoption of sustainable management practices over a two-year period, presumably in response to educational programs, economic considerations and regulatory concerns.

INTRODUCTION

California leads the nation in both nursery and floricultural production with a total gross value of nearly 3.8 billion dollars in 2006, according to the California Department of Food and Agriculture (CDFA, 2007). In California, nursery and greenhouse products are the third highest grossing agricultural commodity (CDFA, 2007).

Ornamental crops typically receive intensive inputs of fertilizer and pesticides to produce vigorous growth and pest-free plants. The intensity of these inputs has led to increasing concern about the management practices and potential water quality impacts of California's nursery industry, especially where production facilities are in close proximity to environmentally sensitive areas. While a variety of good management practices have been recommended for greenhouses and nurseries (Newman, 2008), few studies have documented the extent to which growers have adopted these practices. Previous studies have shown a range in the adoption of good management practices among production nurseries. Surveys of container nurseries in Florida and Georgia, USA, found that 58% and 48%, respectively, collect runoff water (Schoene et al., 2006; Garber et al., 2002), but a study of nurseries in Alabama, found 75% of surveyed nurseries collect runoff water, with this figure being 100% for large nurseries (Fain et al., 2000). A survey of integrated pest management (IPM) practices among nurseries in Pennsylvania used cluster analysis

to group growers into *IPM savvy*, *Part-time IPMer*, and *Reluctant IPMer* categories (Sellmer et al., 2004). While this study found that many nurseries commonly adopted IPM practices, the authors suggested adoption could be increased through education, particularly topics concerning the economic advantages of some IPM management practices and environmental regulations affecting nurseries (Hoover et al., 2004). Based on these studies, understanding the current adoption of good management practices and the willingness of nurseries to further adopt good management practices is important for developing future education and research programs. The purpose of this study was to determine the extent of adoption of good management practices among container nurseries with greenhouse facilities in Ventura County, CA, USA and to determine if adoption would increase in response to operator education.

MATERIALS AND METHODS

Survey Methods

Thirty-eight production nurseries in Ventura County, CA, USA, completed a 142-question assessment to evaluate the current adoption of good management practices. Surveyed sites included only those production nurseries with some greenhouse, hoophouse, or shadehouse facilities, and with at least 80% of their production area devoted to container plants. Questionnaires were completed during 2004 and 2005 during on-site interviews with University of California Cooperative Extension (UCCE) staff so that any questions respondents had about each practice could be addressed immediately. In addition to this educational interview with UCCE staff, many of the surveyed operators then attended at least one educational meeting addressing sustainable management practices, government regulations, and economic implications of good management practices. The same operators were then surveyed again with the same questionnaire within 13 to 24 months. In the questionnaire, 'yes' responses indicated the adoption of a good management practice, 'no' responses indicated that the practice was not adopted, and 'N/A' indicated that the practice would not be applicable at the site. It is understood, however, that because individual operations vary, not every applicable practice is desirable at every site.

Statistical Analysis

'Yes' response rates in the re-survey were plotted against total production area. A Cate-Nelson analysis (Cate and Nelson, 1971; Nelson and Anderson, 1977) was developed for 'yes' response rates in relation to production area. The analysis divided the sites into two populations, determining a threshold production area of 4.0 ha. A threshold 'yes' response rate was determined to maximize the association between these two variables. Fisher's exact test was then applied to determine if there was an association between 'yes' response rates and production area. Fisher's test was conducted with the FREQ procedure in Statistical Analysis Software (SAS) (SAS Institute, 2006).

Survey questions pertaining to good management practices were divided into nine categories, listed in Table 1. Changes in responses between the initial survey and the re-survey were assessed with two statistical methods. For the first method, the number of 'yes' responses for each category for each initial survey was compared with the number of 'yes' responses in the re-survey with a repeated measures analysis of variance (ANOVA). This analysis pools responses across questions within a question category and across respondents. For each question, a 'yes' response meant that a good management practice had been adopted. The analysis was conducted with the MIXED procedure of SAS (SAS Institute, 2006). Data were transformed with $\log_{10}(x)$ or $\log_{10}(a - x)$ functions when necessary to satisfy the ANOVA assumption of normality of residuals. The second method compared the frequency of 'yes', 'no' and 'not applicable' ('N/A') responses for each individual question between the initial survey and re-survey with a test of marginal homogeneity. This analysis employed a log-linear repeated measures model for categorical data conducted using the CATMOD procedure of SAS (SAS Institute, 2006).

RESULTS AND DISCUSSION

Production Area and Adoption of Good Management Practices

Production area among surveyed nurseries ranged from 0.10 to 81 ha, with a median of 4.7 ha (data not shown). The frequency of 'yes' responses to management practice questions was related to production area with a Cate-Nelson plot (Fig. 1). This analysis indicated that respondents with a production area less than 4.0 ha were likely to have 'yes' response rates less than 65%. A Fisher exact test confirmed association of 'yes' response rate and production area when the population of respondents was divided in this manner ($p=0.0001$). These results are supported by Fain et al. (2000) who found large apparent differences in the adoption of certain management practices among small, medium, and large nurseries. Smaller nurseries may adopt fewer good management practices than do larger nurseries due a lack of resources, education or personnel dedicated to specific types of practices, such as irrigation management or pest management. Comparing Quadrants II and III of this plot suggest that respondents with a production area greater than 4.0 ha threshold were more likely to have 'yes' response rates greater than 65% (Fig. 1). These observations suggest that practices appropriate to nurseries of all sizes should be considered, but that particular attention in education, outreach, and research activities should be paid to practices suitable for smaller nurseries. Additionally, large nurseries with low rates of adoption of good practices should also be addressed. These operations may have the potential for large impacts and also the availability of trained personnel to implement good practices.

Adoption of Good Management Practices among Question Categories

'Yes' responses to questions varied among management practice categories (Table 1). 'Yes' responses to management practice questions in the re-survey were $\geq 65\%$ for six categories, including irrigation management, container media management, and fertilizer management. Response rates for questions concerning runoff management, field soil management, and leaching management, however, were only 21, 22 and 35%, respectively (Table 1). It should be noted, however, that these categories also had the highest 'N/A' response rates: 37, 66 and 45%, respectively. Overall, the 'yes' response rate for management practice questions was 65%, and 'N/A' responses was 38% (Table 1). These observations suggest that good management practices were widely adopted by the nurseries in this region when appropriate. However, for the runoff management, field soil management, and leaching management categories, this conclusion is dependent on the appropriateness of 'N/A' responses from respondents.

Changes in Adoption of Management Practices between Initial Survey and Re-Survey

During the survey and re-survey periods, educational opportunities for operators included 14 educational meetings conducted by UCCE staff. Twenty-five of the participating nurseries sent at least one participant to at least one of these meetings, with the average for these 25 nurseries being 3.4 meetings attended per nursery. Increases in the 'yes' responses between the initial survey and the re-survey were found for eight of nine question categories, and for management practice questions overall ($p<0.05$) (Table 1). Only the leaching management category had no increase in 'yes' responses ($p \geq 0.05$). Among the question categories, significant changes ($p<0.05$) indicating increased adoption of good management practices were found in responses to 20 individual questions (data not shown). Practices with increased adoption included collecting runoff water, testing runoff and maintaining records of runoff quality. Other practices with increased adoption included the use of pressure compensating emitters, testing container growing media, and the use of diagnostic laboratory services for pest identification. At least one question with significant changes was found in each question category except the field soil management category (data not shown). These results suggest that nurseries are amenable to the adoption of sustainable management practices over a short duration,

possibly in response to completing the questionnaire, attending additional educational meetings, economic considerations or increasing regulation.

CONCLUSIONS

Good management practices were widely adopted by surveyed nurseries in this region. Question categories with good management practice adoption rates greater than 65% included irrigation management, fertilizer management, and integrated pest management. Smaller nurseries were less likely to have high management practice adoption rates, suggesting that particular attention should be paid to the concerns of smaller nurseries in planning education, outreach and research activities. Surveyed nurseries increased their adoption of good management practices in all management practice categories except for leaching management. Specific practices with increased adoption included some in integrated pest management, runoff management and container media management. Practices with increased adoption included collecting runoff water, testing runoff and maintaining records of runoff quality. These results suggest that nurseries are amenable to the adoption of sustainable management practices over a short duration, presumably in response to education, economic considerations and regulatory considerations.

Because surveyed nurseries were from a limited geographic area and included only those facilities with production dominantly in containers and with greenhouse facilities, it is not known if these results are applicable to nurseries from a wider geographic area or with more diverse production methods. Future work is planned to survey a greater variety of production nurseries within Ventura County and to include facilities within other counties in southern California.

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Tables

Table 1. Summary of responses to a management practice questionnaire for container nurseries with greenhouse facilities in Ventura County, CA, USA. A 'yes' response indicated that a good management practice was adopted.

Question Category	Questions	'Yes' responses (%)		<i>p</i> -value of change	'N/A' [†] responses
		Initial	Re-survey		
Irrigation mgmt.	26	60	68	<i>P</i> <0.001	17
Leaching mgmt.	4	35	35	n.s.	45
Runoff mgmt.	6	11	21	<i>P</i> <0.05	37
Field soil mgmt.	6	18	22	<i>P</i> <0.05	66
Container media	3	52	65	<i>P</i> <0.01	11
Nutrient assess.	5	63	75	<i>p</i> <0.01	4
Fertilizer mgmt.	11	66	71	<i>P</i> <0.05	19
IPM	33	64	73	<i>P</i> <0.001	11
Property mgmt.	39	64	71	<i>P</i> <0.01	18
All	133	58	65	<i>p</i> <0.001	38

[†]N/A=not applicable.

Figures

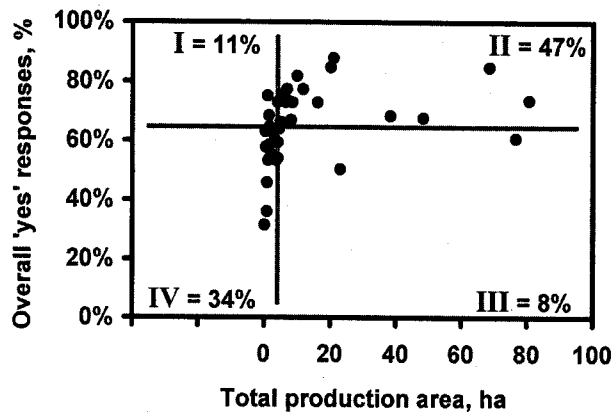


Fig. 1. Cate-Nelson plot of 'yes' response rate to questions about good management practices in relation to production area for 38 surveyed container nurseries in Ventura County, CA, USA. Vertical line separates sites into two populations based on their production area and 'yes' response rates. Horizontal line minimizes the number of observations in Quadrants I and III. Quadrant IV represents small nurseries (area < 4.0 ha) with 'yes' response rates < 65% and Quadrant II represents larger nurseries (area ≥ 4.0 ha) with 'yes' response rates $\geq 65\%$. Quadrants I and III represent nurseries not meeting these criteria. Dividing the respondents in this way produced a significant test of association using Fisher's exact test ($p=0.0001$). Percent values indicate the portion of observations in each quadrant out of the total number observations (38).

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