A SURVEY OF NURSERY WATER QUALITY BEST MANAGEMENT PRACTICES IN OKLAHOMA

By

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LITERATURE REVIEW

Introduction

Andrew Jackson Downing said "Horticulture strongly contributes to the development of local attachments. It is the most powerful thing that civilized man has yet found to charm him to one spot of earth. It contains the mind and soul of the man, materialized in many of the fairest and richest forms of nature."

Society has an appreciation of horticulture such that it will always exist, no matter what changes occur to the industry or it's practices. Therefore, modern nurseries have the challenge of continuing to provide quality plant material to the public at competitive prices as changes occur constantly. As technology progresses and new species are added to the assortment of available plants, along with them come more insects and diseases. This means more pesticides are needed as well as alternative means of protecting those plants from insects and diseases while avoiding further pollution of the environment.

History of Nurseries in Oklahoma

Nursery operators have always been concerned about pest problems (Garber and Hudson, 1996). The initial goal of nursery personnel was to employ whatever means necessary to eliminate pests without compromising the plant material's aesthetic attributes. Nursery operators did not consider how those chemicals could potentially impact the environment. Today, goals have evolved to couple good management practices with pest control strategies resulting in a nominal impact on the environment.

Nurseries in Oklahoma range in size from small family operations to large corporate nurseries that wholesale field grown and containerized nursery stock across the nation. A myriad of species are offered that thrive in Oklahoma's climate. However, only a limited number of pest resistant species and cultivars are currently offered to lessen the need for pest control.

Commercial ornamental nurseries pose risks relating to water quality due to high nutrient and pesticide inputs used in production. Pesticides used include not only insecticides but fungicides and herbicides as well. Once risks are identified, measures can be taken to minimize them. Risk reduction measures include best management practices (BMP's), capture and recycle technology (i.e., catching and holding storm water or irrigation runoff, sometimes treating and reapplying), and low fertilizer and pesticide input plants. Best management practices are devised and selected to increase productivity, decrease pollution, and make an operation run more efficiently overall. Many BMP's are applied common sense actions while others involve more complex directives. Capture and recycle technology is a method of recycling irrigation water to nearly eliminate nursery effluents and the potential for contaminating ground and surface waters, while providing other benefits as well. A basic system captures runoff at low points in a nursery, then pumps it to storage ponds at higher points for redistribution (von Broembsen, 1998). If plant pathogens are a threat, the water can be treated before redistribution to improve water quality and subsequent plant growth.

Based on a survey in 1989, the nursery industry clearly indicated that adequate clean water was more important than an independent business climate (Urbano, 1989). This attitude indicated that nursery personnel were willing to make an effort to protect their water resources, even with greater capitol input. However, nursery personnel also indicated they would expect more efficient irrigation systems to pay for themselves within five years of installation (Uva, et al., 1998).

Irrigation Types

Conserving water and preventing leachates from polluting ground and surface waters can both be accomplished in part when a nursery applies BMP's. One facet of this regime is capturing, treating, and recycling nursery water from irrigation and storm water runoff. Many nurseries have always captured and recycled irrigation runoff to some extent (Bailey, et al., 1998). These nurseries utilize reservoirs to collect and hold effluents. The collected effluent is pumped out of the reservoir and piped back to be used as is or blended with fresh water. Monitoring of the reservoir is necessary to ensure that it doesn't overflow, which could result in illegal runoff and deleterious effects to the environment.

Another practice to improve irrigation efficiency is cyclic irrigation. This method of irrigation can provide an economic benefit from less water consumption and reduced nitrogen inputs (MacDonald, et al., 1994). Though it has been shown that daily irrigation can produce taller, fuller plants, water-use efficiency was greater with intermittently irrigated plants (Morvant, et al., 1998). With cyclic or pulse irrigation, there are two phases: (1) an operating phase, and (2) rest phase. The quantity of water applied is still the same, but the number of irrigation applications is increased, which decreases the irrigation rate (Gilliam, et al., 1996). The rest phase can also be termed cyclic irrigation (Bilderback and Bir, 1998).

Nutrient Effects

Many studies have been conducted on the nutrient and pesticide effects of cyclic nursery water. C.H. Gilliam showed that total N (nitrogen) leached (Gilliam, et al., 1996) was 47% less with cyclic treatments than with continuous irrigation. Nitrogen leached with cyclic treatments was further reduced 34% in another study (Fare, et al., 1994). The resting phase provides plants time to utilize available water, thus decreasing runoff. This concept has also been utilized with trickle irrigation as opposed to overhead sprinklers. Experiments have shown much less nitrate is leached by trickle (drip) versus overhead sprinklers (Rathier and Frink, 1989). Likewise, data obtained from another study indicated lower levels of NO^3-N (nitrate) in production bed runoff with controlled-release fertilizers compared to a combination of controlled-release and soluble fertilizers (Yeager, et al., 1993). Nitrogen, a frequently limiting nutrient for crop production (Schnelle, 1986), is added in larger quantities to growing media and is one of the most commonly found pollutants.

Greenhouses and nurseries use chemicals and fertilizers that are beneficial for plant growth and pest control. The need to control plant growth and manage pests in this environment is critical (Cuperus and Berberet, 1993), so chemicals are necessary and the risk should be identified. As plants are irrigated, the effluent may have an opportunity to infiltrate the soil and introduce whatever nutrients or chemicals it carries into an aquifer or other water supply. Nutrients have been found at varying rates in wells under much of the country (Gilliam, et al., 1996).

An ongoing study by the Oklahoma Department of Agriculture (The Curtis Report) monitors pesticide and nutrient content of irrigation tailwater along the Illinois River in Eastern Oklahoma (Molnar, 1997). The nurseries affected are commended in the Curtis Report for their efforts to protect the environment and minimize nutrient/pesticide runoff.

Pesticide Traces in Irrigation Water

Pesticide detection is common in rural supply wells, but rarely exceeds regulation maximums (Maas, et al., 1995). Since pesticides are being detected, nurseries should be familiar with pesticide mobility. It is hard to manage pesticide risks because the nature of harm caused by pesticides has changed dramatically as different products have been introduced over time (Benbrooks, 1996). However, if a certain pesticide is detected in recycled water or in aquifers, a substitute could be obtained in most situations.

Weed control agents, or herbicides, specifically merit study as well. Aquifer studies revealed detectable traces of herbicides in 24% of samples collected (Burkart and Kolpin, 1993). However, evidence exists that formulations from herbicides do not accumulate in containment pond water (Camper, et al., 1994). When a chemical is applied there is no method of getting 100% efficiency, especially if nursery stock is irrigated shortly after the application. Maximum herbicide residues have been detected within the first 15 minutes of water runoff, rapidly decreasing thereafter (Keese, et al., 1994). After applying a herbicide, it is beneficial to wait the greatest possible amount of time before irrigating. Water quality degradation usually takes place gradually over a long period of time and can be overlooked even by experienced growers (Fitzpatrick and Verkade, 1987). Water degradation with pesticide residues then leads to other risks.

Phytotoxicity

Other risks concerning water quality include salinity problems and potential for phytotoxicity. The interaction between fertilization and irrigation should be a major consideration (Wright, 1992). The repeated use of water increases salinity and thus create a potential for phytotoxicity and pollution of surface or ground water (Horowitz and Elmore, 1991). In addition, the repeated use of water increases the potential for disease contamination. Pathogen contamination is acknowledged as a widespread and significant problem, specifically with the recirculation of crop effluents. Propagules of the species

Phytophthora have been detected and may pose a threat to the plants with which they come in contact with (MacDonald, et al., 1994).

Risks of Nurseries

Risk assessment in the nursery industry can be used to determine the risks that pose a sufficient threat to warrant action. As society creates more risks and pollution and population grow, exposure becomes increasingly unavoidable and risk assessment/management to mitigate these risks become increasingly important. Previously, risk assessments were based on statistical data (Parris, 1987), but now factors like the toxicity of the hazard and quantity of the toxic substance are included. The majority of nursery operators nationwide were relatively unaware that there was a problem with their use of water (Mezitt, 1992).

Specific aspects that influence risk in the nursery are: media used, topography, on-site wells, plants grown, pesticides, fertilizers, and even the vehicles driven (pertaining to gas and oil leakage). Though not direct risks, they pose an inherent risk because many years of repeated exposures create a significant threat as a part of the overall picture. All factors should be considered when assessing risk to determine how to manage for it. Media used and topography have an effect on how quickly water (and chemicals) will percolate into the ground and possibly pollute aquifers and other water sources. On-site wells present direct pathways into aquifers. Plants grown in a nursery have different water and fertilizer requirements as well as pesticide needs. While some plants may be prone to certain types of insects, others are insect resistant with no need for pesticides. Pesticides and fertilizers are the contaminant in many drinking water supplies which can lead to human diseases/disorders. Other minor factors could be significant when accrued consequences are considered over time.

Solutions

Once the risks are identified, nurseries can implement practices to eliminate, or at least mitigate, the majority of risks. Recycling irrigation water can reduce leaching and runoff, as well as conserve water (Fare, et al., 1994). Since the primary risks are those associated with contamination of water systems, the greatest emphasis should be placed on preventing this from occurring. Other management practices to lesson risks in a nursery include using media not susceptible to quick infiltration by water or using high clay content soils for example. Highly porous soils and shallow water tables require additional care (Schnelle, et al., 1998). Fertilizers and pesticides should always be applied according to label instructions in proper amounts. On-site wells should be properly sealed and backflow prevention devices should be installed and checked periodically.

The Environmental Protection Agency (EPA) considers pesticide risks to come from application, runoff, and residues of pesticides in contact with humans and the environment (Carney, 1990). Environmental regulations are stricter than ever before; this trend will likely continue. Environmental laws were created primarily in the 1970's and 1980's; in the 1990's they are being diligently enforced (Chilcutt, 1995). Currently, the EPA is in the process of modifying risk assessment methods that can lead to stricter regulations (Barolo, 1997). Stricter regulations means more enforcement, which is an incentive for better management by the nursery industry.

CHAPTER II

A SURVEY OF NURSERY WATER QUALITY BEST MANAGEMENT PRACTICES IN OKLAHOMA

Introduction

A statewide nursery water quality best management practices (BMP's) survey was designed to determine strengths and weaknesses of the nursery industry in Oklahoma with respect to preventing environmental contamination. The primary emphasis was on water quality. Therefore, the survey focused on water quality aspects and what could be done to provide nurseries better service. Growers at various economic levels, retail and wholesale, were queried to assess their current implementation of best management practices. Also, strategic actions (including BMP plans) that could potentially affect current and future water quality standards were investigated.

Areas such as the physical environment of the nursery, use of pesticides and fertilizers, integrated pest management (IPM) practices, and employee safety training were included in the survey. Other aspects germane to preserving and protecting current water quality and related environmental issues were also included (Appendix A).

The objectives of this project are: (1) to administer a statewide nursery water quality best management practices survey to determine the strengths and weaknesses of the Oklahoma nursery industry with respect to preventing environmental contamination (with an emphasis on water quality), (2) to determine Oklahoma nursery personnel's educational needs, and (3) to discover avenues to provide them better and more timely information.

This work was undertaken not only to determine Oklahoma growers' current level of sophistication in environmental stewardship, but also to establish a baseline for the determination of future research and training thrusts. This data will aid in workshop and material preparation for future educational events.

Materials and Methods

A survey was administered on-site to 75 of over 200 nursery operations in Oklahoma. The operations were identified from the Oklahoma Nursery/Floral License Directory published by the Oklahoma Department of Agriculture. Surveys were administered at random until the target number was acquired. The target number of 75 surveys was determined to be a statistically valid representative sample of the population and was deemed a feasible goal due to logistical limitations (Steel et al., 1997). The survey was administered in person to achieve the highest quality data and response rate. Sample size was determined from the standard sample size calculation formula to have a 95% confidence interval of $\pm$ 9% (Warde, 1990). Initially, nursery operators were contacted to determine their willingness to participate and to schedule a meeting where the survey was administered. Data was compiled and analyzed using Microsoft Excel®.

The survey was organized into eleven specific categories as follows: (1) General Information, (2) Wellhead Considerations, (3) Production Considerations, (4) Nursery Layout, (5) Storage and Handling of Potentially Hazardous Materials; Pesticides, (6) Plant Production and Maintenance Practices; Pest Management, (7) Nutrient Management, (8) Irrigation, (9) Employee Safety Training, (10) Design Considerations, and (11) Sales Information. These areas were included because they encompass all major potential vehicles for pollution from a nursery. Data from these categories were useful in determining the physical nature of the nursery site as well as the history of the site and whether pollution may have occurred.

These categories were determined to be critical in ascertaining which best management practices, if any, were being implemented by Oklahoma nursery personnel. The first section of the survey focused on general information and the physical environment of the nursery. This information was included for purposes of categorizing nurseries by size and type of sales (retail versus wholesale, container versus field grown). Soil type, parent material, topography, drainage points, adjacent land use, surface water, septic systems and other pertinent information were included.

Following the physical environment section were questions pertaining to wellhead considerations. These included drinking water wells, abandoned wells, well depth, and how recently nursery irrigation water had been analyzed for nitrogen content. The survey also contained questions whether OSU could help with any well issues or related concerns. These issues all pertained to potential aquifer contamination as well as safety.

The production considerations section focused on irrigation. Its purpose was to determine the maximum estimated volume of water used per day as well as how nursery personnel select and manage irrigation frequency and amount. The method of irrigation was considered in terms of a time-based schedule versus irrigation based upon physiological plant need. This was to determine whether nursery operators were making an effort to conserve water predicated on plant need as opposed to a scheduled irrigation which could be less efficient. Additional topics included whether primary fertilizers were used, and methods and frequency of application. Other questions included whether fertilizers were incorporated in the mix, and if the nursery operators monitored the nutrient content of irrigation runoff.

The total size of the site, percent covered with impervious surfaces, and the presence of retention ponds were topics in the nursery layout section. Also included were questions about the contour of production areas, as well as which materials were used to slow runoff and increase infiltration.

Another section focused on pesticides. Questions ranged from the type of pesticides used to how they were applied, and whether pesticide selections were based on leaching and runoff potential considerations. This section also contained questions pertaining to disposal of pesticide containers and rinse water, pesticide storage, and pesticide mixing/loading areas. Other questions included the fate of runoff from pesticide and fertilizer storage areas and whether backflow prevention devices were present and periodically tested.

Not only were pesticide application issues queried, but pest management was also determined an important area to survey. The term integrated pest management (IPM) describes techniques for pest control using sound best management practices for a more efficient method of pest control. Determining if the staff were trained in IPM principles, as well as who they ask for help when they have a plant selection/plant management question were priority objectives. This section also provided a checklist of IPM practices for the nursery manager.

The next section (nutrient management) concentrated on determining how often soils and growing media were tested to verify the need for nutrients. Also covered were slow release fertilizers, superphosphate as a media amendment, split applications, and fertigation. Sources of water and methods of irrigation used in the nursery were addressed as well.

Employee safety training was a section designed to highlight management practices that ensure employee safety as well as the safety of consumers or other exposed individuals. These standards included training all employees on pesticide spills, providing protective clothing, maintaining accessible eye washes, showers, and respirators, and prominently displaying all appropriate warning signs. It also included whether nursery owners maintained material safety data sheets (MSDS) and conducted meetings on the proper use of safety equipment.

Nurseries that performed landscape design were asked whether they installed erosion and sediment controls, instructed clients with irrigation systems on proper timing of irrigation to conserve water, and if lawn irrigation areas were segregated from other planted areas.

The final section of the survey contained sales information. This information was reported in aggregate to ensure anonymity of the nurseries and was used to categorize the nurseries by size, type, and amount of sales for comparative purposes. The number of employees working at the establishment was included in this section. The primary outlet (if the nursery had more than one growing/retail outlet) was asked as well.

Results and Discussion

The mean size of the nurseries was 44 acres whereas the median size of nursery sites surveyed was four acres. The majority of sites were 10 acres or less, but the few large operations surveyed had several hundred acres thus skewing the mean size. On average, six percent of each site was covered with impervious surfaces. Twenty-one percent of surveyed nurseries had retention ponds, settling basins, or artificial wetlands to capture nursery runoff and allow for decomposition of pollutants. Over half of the nurseries had contoured or graded production areas to mitigate runoff and increase water infiltration. A majority (75%) of nursery stock holding areas were surfaced with materials that slowed runoff and increased water infiltration. These materials ranged from gravel to wood chips. Most (55%) nurseries planted grass filter strips between nursery rows or blocks to further minimize runoff and transport of pesticides from entering groundwater or local surface water sources. These data indicate that nursery operators were making an effort to reduce runoff and increase water infiltration.

Survey results indicated that nursery personnel in Oklahoma were interested in becoming proactive in maintaining or restoring high water quality standards while maintaining their reputations for producing superior nursery stock. Based on the survey responses, their motivation was twofold; firstly to be environmentally responsible and secondly to respond to public concern about excessive use of fertilizers and/or pesticides. These goals were not only feasible but were revealed as being realized by leading Oklahoma growers.

The compiled data indicated that although many nurseries were proactive in their approach to environmental issues, the majority of smaller nurseries (particularly retail operations) did not consider the possibility of adjusting routine practices within their operation for environmental purposes.

The results of the general information section are as follows: over 86% of surveyed nurseries dealt primarily with container grown plants opposed to 14% that grew field grown stock (Table 2.1). Twenty-nine percent of the nurseries were solely wholesale with the balance (71%) operating as retail outlets. Primary soil types indicated were clay (35%), sandy loam (20%),and clay loam (9%), with other miscellaneous soils comprising 36% of the balance (Table 2.2). Limestone was listed as the primary bedrock type amongst growers (Table 2.3). Drainage points were primarily sewer/storm drains for nurseries within city limits, and creeks or lakes for rural nurseries (Table 2.4). Rural nurseries used septic tanks while urban nurseries had access to municipal sanitary sewer systems.

Table 2.1 Nursery Types Surveyed

Production Method	Percent (%)
Container Grown	86
Field Grown	14
Sales Types	
Retail Nurseries	71
Wholesale Nurseries	29

n=75

Table 2.2 Nursery Soil Types

Soil Type	Percent (%)	95% CI (%)
Clay	35	(22-48)
Sandy Loam	2	(9-31)
Clay Loam	9	(1-17)
Other	36	(23-49)

n=55

Table 2.3 Types of Bedrock as Listed by Survey Respondents

Bedrock Type	Percent (%)	95% CI (%)
Limestone	34	(20-48)
Sandstone	2	(0-6)
Shale	2	(0-6)
Other	29	(16-42)
Unsure	33	(19-47)

n=45

Table 2.4 Nursery Drainage Points for Runoff Water

Drainage Point	Percent (%) (%)	95% CI (%)
Natural Drainage	37	(25-49)
Creeks/Rivers	23	(13-33)
Lagoons/Ponds	5	(0-10)
Storm/Sewer Drains	29	(18-40)
Other	6	(0-12)

n=65

Of nursery operators surveyed, 54% indicated that there were other proximal wells, particularly of drinking water quality. Of those with abandoned wells on-site, only 34% were properly sealed. Seventy-seven percent of functioning wells were properly cased whereas the remaining 23% were either improperly cased or their status unknown by the surveyee. An average well depth of 100 ft. was reported. Most growers failed to keep records in respect to time transpired since their water source was last tested for nitrates, bacteria, EC, pH, cations, etc. Only 8% of those surveyed had well issues or concerns in which they requested assistance from OSU, which suggests that growers didn't want to draw attention to any potential problems if they weren't previously obvious.

In the production considerations section, the data revealed 32% of growers metered their wells or other water supply to measure water use. A small fraction of those growers tracked the daily water usage. Approximately 86% of growers irrigated based on plant need opposed to 14% that irrigated on a pre-determined schedule. Growers who irrigated based on plant need admitted that routine scheduling was difficult to abandon altogether since many plants require irrigation every day in the summer. The primary irrigation type was hand watering (45%); overhead irrigation comprised 36% of all irrigation (Table 2.5). Sources of irrigation water included municipal (54%), groundwater (33%), captured rainfall (6%), and streams/lakes (7%) (Table 2.6).

Most nursery operators incorporated fertilizer in the soil mix or used commercial media with pre-mixed fertilizer. Application rates and timing of

Table 2.5 Primary Irrigation Types for Surveyed Nurseries

Irrigation Type	Percent (%)	95% CI (%)
Hand Watering	45	(34-56)
Overhead Irrigation	36	(25-47)
Drip	15	(7-23)
Other	4	(0-9)

n=72

Table 2.6 Sources of Irrigation Water

Water Source	Percent (%)	95% CI (%)
Municipal	54	(43-65)
Wells	33	(22-44)
Captured Rainfall	6	(0-11)
Streams/Lakes	7	(1-13)

n=73

irrigation cycles were calculated to minimize movement of fertilizers and pesticides by 73% of growers. Twenty-eight percent of respondents knew their irrigation water pH, which averaged 7.05. Also, 19% of surveyed nursery operators monitored nutrient content of irrigation runoff.

The primary pesticides used include glyphosate, diazinon, malathion, acephate, and chlorpyrifos. Some nurseries avoided chemical control altogether. At such nurseries, people felt strongly about the environment or perceived the risks of using chemicals as outweighing the benefits. Virtually all nurseries selected pesticides based on what worked rather than its particular leaching and runoff potential. Those that anticipated risks for potential contamination were larger wholesale nurseries.

Pesticide application methods in most small nurseries consisted of a hand sprayer. The staff of larger nurseries used boom sprayers. Less than 24% of nursery operators indicated that they selected pesticides based on their leaching and runoff potential. The primary method of disposing of empty pesticide containers was triple rinsing and discarding as normal refuse. Spraying excess pesticide mixture was the most common method of disposal, as few nurseries dedicated tanks for reserving excess solutions or rinse water. When asked to characterize pesticide storage, 85% had a secured, locked building. Seventy-seven percent of the nursery operators stored pesticides in areas with impermeable floors. Only 33% of nursery operators indicated that floor drains were present in their pesticide storage areas. A majority (70%) indicated their operation was equipped to clean up a pesticide spill in all storage, mixing, production or sales areas of their operation. Of those operations with outdoor pesticide mixing sites, 51% provided overhead coverage. Fifty-four percent of nurseries had an impermeable mixing/loading area and 17% had floor drains. Backflow prevention devices were present in 69% of nurseries, but only 40% of those tested them regularly.

Results indicated that nurseries fully implemented few BMP's, but had adopted fundamental IPM approaches. Integrated pest management consists of many "common sense" approaches to pest management that were currently being implemented, even in nurseries that didn't maintain a specific IPM plan. Nevertheless, 66% of nurseries claimed to have a specific IPM plan. Generally, only the owner/manager or growers were trained in IPM but 70% had staff that had some knowledge of IPM. More than 73% of nurseries surveyed indicated an interest in a program designed to assist growers in marketing pest resistant plant materials. Sources of help for growers included books, OSU personnel, and family or co-worker advice. Table 2.7 shows IPM practices implemented by nursery growers. These data reveal that the majority of nursery personnel implemented at least some IPM practices. Though only 66% of nurseries acknowledged having a designated IPM program, a much higher percentage of nurseries actually implemented IPM practices.

Of those with scouting/monitoring programs, 66% scouted daily, 6% twice a week, 21% weekly, and 6% used yellow sticky traps (Table 2.8). This shows that the majority of Oklahoma nurseries scout daily for insects. Sixty-four percent indicated interest in participating in a program on marketing pest resistant plant

Table 2.7 IPM Practices Implemented by Nursery Personnel

IPM practice	Percentage (%)	95% CI
	(%)	(%)
Had an IPM program **n=65**	66	(54-77)
Staff was trained in IPM principles **n=53**	70	(57-82)
Stocked pest resistant plant materials **n=68**	81	(72-90)
Used economic threshold levels **n=65**	85	(76-94)
Evaluated alternative pest controls **n=64**	78	(68-88)
Maintained a resource library **n=67**	94	(88-99)
Used least toxic pesticides **n=60**	78	(68-88)
Maintained a weed-free barrier **n=59**	75	(64-86)
Inspected incoming stock **n=66**	97	(93-100)
Had a scouting/monitoring program **n=70**	89	(82-96)

Table 2.8 Scouting Frequency for Nurseries with Insect Scouting Programs

Frequency	Percent	95% CI
	(%)	(%)
Daily	67	(54-80)
2x Week	6	(0-13)
Weekly	21	(9-33)
Other	6	(0-13)

n=47

materials in cooperation with OSU, Stillwater. When precipitation was expected within 24 hours, fertilizer and pesticide applications were delayed by 94% of the respondents. Warning signs were posted to alert customers or employees of recent chemical applications in 73% of nurseries.

In nutrient management issues, nursery owners didn't periodically test growing media for nutrients (Table 2.9). Over 90% indicated that they used slow release fertilizer (Table 2.10) and the majority of those used Osmocote®. Superphosphate was incorporated in organic potting media by 16% of surveyed growers and total fertilizer amounts were applied in split applications by 61%. Over half of nursery operators used fertigation (injecting fertilizer into irrigation water).

The employee safety training section results are reported in Table 2.11. A conclusion can be drawn from these results that the majority of nursery operators maintained and implemented employee safety equipment and training. However, nursery record-keeping in the area of safety training and hazardous materials was significantly lower. Nurseries that also provided design and landscaping services were asked water quality questions relating to design considerations. Those that installed erosion and sediment controls to minimize soil erosion were 66%, whereas 84% instructed clients with irrigation systems on the proper timing of irrigation to conserve water. Furthermore, 89% of designers separated lawn irrigation areas from other planted areas.

Table 2.9 Frequency of Soil Tests

Frequency	Percent (%)	95% CI (%)
As Needed	7	(1-13)
> Semiannual	7	(1-13)
Semiannual	12	(4-20)
Annual	12	(4-20)
Every 2 to 5 Years	7	(1-13)
Seldom	22	(12-32)
Never	33	(22-44)

n=65

Table 2.10 Types of Fertilizers Used

Fertilizer Type	Percent (%)	95% CI (%)
Osmocote	84	(74-94)
Water Soluble	12	(3-21)
Other	4	(0-9)

n=52

Table 2.11 Employee Safety and Training Practices Implemented

Practices Implemented	Percent (%)	95% CI (%)
Trained and verified that all employees handled pesticides properly **n=60**	80	(70-90)
Provided protective clothing and trained in proper use **n=58**	86	(77-95)
Maintained accessible eye washes **n=57**	80	(70-90)
Maintained accessible showers **n=56**	75	(64-86)
Maintained accessible respirators **n=58**	71	(59-83)
Had MSDS on file **n=57**	81	(71-91)
Prominently displayed all appropriate warning signs **n=56**	68	(56-80)
Documented and maintained records of safety training and meetings **n=58**	45	(32-58)
Had a written hazard communication plan **n=55**	35	(22-48)

Summary

Survey results indicate that Oklahoma nurseries had strengths in implementing fundamental IPM approaches. BMPs such as mulching and maintaining grass filter strips were common practice. Training employees on safety issues and maintaining proper safety equipment also were also strengths. Other commendable practices included irrigation management and water conservation. General pesticide storage and mixing issues met current stardards, but could be improved.

Weaknesses include organization of IPM and BMP programs and record-keeping in the area of safety training. Monitoring soil nutrients and consideration of pollutants after they enter the ground or run off the nursery (i.e. preventive methods such as storage ponds) were weaknesses as well.

Educational needs of the Oklahoma nursery industry were primarily limited to smaller operations. Nursery personnel could benefit from more information on proper BMP's as well as ways to implement IPM programs. Other valid information may include more efficient methods of irrigating and environmentally sound practices that would also save money for the nursery operator.

Future Work

Future work should focus on assisting nurseries with environmentally-based educational programs. Such programs could provide training for protecting natural resources while still allowing growers to realize a profit.

Additionally, a marketing program designed to promote low chemical input plants would be advantageous.

The stage is set for the implementation of the next phase of expansion and refinement into ecologically-based programs such as propagation and sale of low pesticide input plant materials, improved cultural practices, and the integration of environmentally sound management approaches. For example, many growers are in the process of phasing out calendar-based pesticide application programs in favor of aesthetic and/or economic threshold-driven pesticide spray programs. These types of programs pose a challenge for growers to implement, however, especially when information about the success of such programs isn't readily available.

Additional follow-up work should consider these data for planning extensive workshops, fact sheets, brochures, and other literature for the benefit of nurseries statewide. Also, with these results, future surveys can provide a means to measure BMP implementation progress within the nursery industry. After educational programs have been conducted and nursery growers have had time to implement more ecologically sound management practices, the desired effect would be an increase in self-initiated implementation of these types of practices regardless of nursery type or size. Larger, more economically stable operations are more likely to adopt such practices, (Uva et al., 1998). However, through education of demonstrated efficiency, economically challenged growers will have greater incentive to emulate industry leaders as well.

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APPENDICES

APPENDIX A: SURVEY ADMINISTERED TO NURSERY OPERATORS

Environmental Audit
Retail and Wholesale Nurseries

This environmental audit is presented as a tool to evaluate current management practices that may impact the environment, especially water quality. It is designed to lead to awareness, not only of management practices that may require improvements, but also to identify sound management practices that should continue.

The environmental audit is broken down into sections that focus on related management practices, such as irrigation management or pest management. Some sections or questions will not apply for all nurseries or garden centers. Going through these sections and attempting to answer the questions with management personnel provides a convenient and easy way of conducting an assessment.

1. Name of Nursery (Optional)

   ____

2. Name of Respondent, (Optional)

   ____

General Information:

3. Type of nursery: Container % _____ Field % _____
4. Type of Sales Wholesale % _____ Retail % _____
5. Do you know the soil type? ____________________
   is the bedrock limestone? ____ yes ____ no _____ unsure
6. What is the land slope? __________%
7. Does the nursery have drainage points in the form of:
   _____ storm drains
   _____ natural drainage points
   _____ other
8. How far away is the nearest surface water? ______ miles or ______ feet

9. Is the neighboring land use: _____ rural?
_____ urban?
_____ residential?
_____ industrial or commercial?

10. Are there septic tanks in the area?
_____ yes _____ no
If yes, how far away are they? _____________ feet

11. Are your septic systems located an appropriate distance from water sources? _____yes _____no How far? _____________ feet

Well head Considerations:

12. Are there other wells nearby, particularly drinking water?
_____yes _____no

13. Have any abandoned wells on site or in the immediate vicinity been properly sealed? _____yes ______no _____ not applicable

14. If you have a well, is it properly cased? _____yes ______no

15. What is the well depth? ___________feet ___________unknown

16. When was the last time you checked well water (water source) for
___________nitrates?
___________bacteria?
___________EC, pH, cations, etc?

17. Could OSU help with any well issues/concerns? _____ yes _____ no

Production Considerations:

18. Do you have a meter on well(s) or other water supplies to measure water use?
_____yes _____no

19. What is the maximum estimated volume of water used per day?
________gal/day

20. How do you select and manage irrigation frequency and amount? (schedule vs. plant need)___________________________________

If plant need, how do you determine? ____________________________

21. What types of fertilizer(s) do you use? ____________________________

____

How is this material applied? ____________________________________

How frequently do you apply fertilizer(s) to your crops? ______________

22. Are any fertilizers incorporated in the mix? ______________________

23. Do you monitor the nutrient content of irrigation runoff? ___yes _____no

Nursery Layout

24. What is the total size of your site? ______acres.

25. What percentage of your site is covered with impervious surfaces (paved roads and parking lots, roofs etc.): ______% or ______ acres.

26. Do you have retention ponds, settling basins, or man-made wetlands which capture nursery runoff to allow breakdown or settling out of pollutants? ____yes ____no

27. Are production areas contoured, or graded, to slow runoff and increase water infiltration? ____yes _____no

28. Are plant holding areas surfaced with materials that slow runoff and increase water infiltration? _____ yes _____ no
If yes, what materials? ______________________________

29. If field production, are grass filter strips established between rows or blocks to minimize runoff? ____ yes _____ no

Storage and Handling of Potentially Hazardous Materials

Pesticides

30. What pesticides do you use? ________________________________

____

How are these materials applied? ______________________________

31. Do you select pesticides based on their leaching and runoff potentials?
_____ yes _____ no

32. How do you rinse and dispose of empty pesticide containers? _________

____

33. What do you do with rinse water from your equipment/excess pesticide mixture?

____

34. Do you have a tank for reserving left over solutions or rinse water?
_____yes ______no

35. Characterize pesticide storage:
    secured (locked) building _____yes _____no
    impermeable floors _____yes _____no
    floor drain _____yes _____no
    distance from any water source (e.g., a well) ___________ feet

36. Is your operation equipped to clean up a pesticide spill in all storage, mixing, production or sales areas of your operation? ____ yes ____ no

37. *If outdoors*, does your pesticide mixing site have a roof over it?
____yes _____no

38. Do you have an impermeable mixing/loading area? _____yes _____no

39. Do your mixing, growing and application sites have floor drains?
____yes _____no

40. How far Is mixing done from wells and other water sources? ______feet

41. Are water sources fitted with backflow prevention devices? ___ yes ____no
Are they tested periodically? _____ yes _____ no

42. Where will runoff go from your pesticide and fertilizer storage areas?

____

43. Could you capture or divert runoff from these areas? ____ yes ____no

Plant Production and Maintenance Practices

Pest Management

44. Do you have an Integrated Pest Management (IPM) plan? _____ yes _____ no

45. Is your staff trained in principles of integrated pest management (IPM)? _____ yes _____ no

46. If you have a plant selection/plant management question, who do you ask for help?

    ____

47. Do you use the following Integrated Pest Management (IPM) practices:

pest resistant plant materials	_____yes	______no
economic threshold levels	_____yes	______no
evaluation of alternative controls	_____yes	______no
calendar-based sprays	_____yes	______no
maintain a resource library	_____yes	______no
use least toxic pesticides	_____yes	______no
maintain a weed-free barrier	_____yes	______no
inspect incoming stock	_____yes	______no

48. Do you have a scouting/monitoring program? _____ yes _____ no
    If yes, how often are plants scouted? Examples: once a week, every two weeks, once a month, etc. ______________________________

49. Would you be interested a program on selling and marketing pest resistant plant materials in cooperation with OSU, Stillwater? _____yes _____no

50. Are fertilizer and pesticide applications made to avoid being applied when precipitation is expected within 24 hours? ____yes ____no

51. Are warning signs posted to alert customers or employees of recent chemical applications? ____yes ____no

52. Is overhead irrigation postponed after chemical application? ____yes ____no

53. What is the pH of your water source? _______ pH _____ unknown

54. How often do you calibrate application spray equipment? ____________

Nutrient Management

55. How often are soils and growing media tested to verify the need for nutrients?

    ____

56. Do you use slow or controlled-release fertilizer when appropriate?
    ____yes ____no If so what? ______________________________

57. Do you incorporate superphosphate in organic potting media? ___yes
    ___no

58. Are total fertilizer amounts applied in split applications? ____yes
    ____no

59. Do you inject fertilizer in your irrigation water? ____yes _____no
    If so, have you looked at alternatives, or other practices which may reduce nutrient leaching and runoff, e.g capture and re-use of irrigation water?
    _____yes _____no

Irrigation

60. What are your sources of irrigation water:
    _____Groundwater/spring-fed wells
    _____Captured rainfall/runoff
    _____Stream/lake/reservoir
    _____Artesian/deep wells
    _____Municipal water supply
    _____Other

61. How are your crops irrigated in the nursery/garden center? (not greenhouse)

Percent	type of irrigation
_____	drip
_____	sub
_____	hand watering
_____	overhead sprinklers
_____	other

62. Do you control application rate and timing of irrigation to minimize movement of fertilizers and pesticides? (Example: Pulse irrigation: Applying water in several shorter intervals rather than one long period has been demonstrated to reduce runoff and nutrient leaching.)
    ____yes ____no

Employee Safety, Training

DO YOU:

63. Train and verify that all employees are properly handling pesticides and fertilizers, and educated on how to clean-up accidental spills?
_____yes _____no

64. Provide protective clothing, eye protection and safety equipment, and train all employees in proper use? ____yes ____no

65. Maintain accessible eye washes? ____yes _____no
showers? ____yes _____no
respirators? ____yes _____no

66. Have Material Safety Data Sheets (MSDS's) on file and readily available to employees for all hazardous materials including pesticides, ammonia and gasoline used in your operation? ____yes ____no

67. Prominently display all appropriate warning signs? (in English and Spanish if appropriate.) _____yes _____no

Documentation

68. Do you document and maintain records of safety training, safety meeting subjects and attendance? ____yes ____no

69. Do you have a written hazard communication plan? ____yes ____no

Design Considerations

70. Do you install erosion and sediment controls, such as silt fences or mulch to minimize soil erosion if soil is left bare on a job site for more than one or two weeks after grading? ____yes ____no

71. Do you instruct clients with irrigation systems on the proper timing of irrigation to conserve water? _____ yes _____ no

72. Are lawn irrigation areas separated from other planted areas? ____yes ____no

Sales Information ** Remember this survey is completely confidential, and any information, name or business will not be made public

73. How many employees currently work at your nursery? ______________

74. What percent of sales is : _______Plant Materials
_______ Hard Goods
_______ Design/Maintenance

75. Where are your primary outlets? (Which location has the most sales?)

____

76. What are your gross sales annually? ___________________________

Thank you for your time and input.

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

DATE: 01-25-99 **IRB #: AG-99-010**

Proposal Title: A SURVEY OF NURSERY BEST MANAGEMENT PRACTICES IN OKLAHOMA

Principal Investigator(s): Mike Schnelle, Cody White

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Signature: Carol Olson

Carol Olson, Director of University Research Compliance

Date: January 25, 1999

cc: Cody White

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

2

VITA

Cody J. White

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Master of Science

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