Framework for a Systems Approach to Nursery Certification
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"A system is an entity, which maintains its existence through the mutual interaction of its parts."
Ludwig von Bertalanffy, Austrian Biologist (1901–1972)

INTRODUCTION: The Systems Approach to Nursery Certification (SANC) is an enhanced strategic methodology to meet the many challenges in the movement of plants within the environment of regulatory agriculture and business activities. Plant pests and pathogens are undesirable yet potential accompanists to plants that are moved in the domestic, interstate and international trade. The common business model is well suited to growing small to large numbers of desirable plants for propagation or sale and moving them from vendor to buyer over small and long distances. It is encouraging that the everyday nursery may well incorporate several elements of a systems approach to mitigating the risk and effects of nursery pests. As the challenges of escalating costs of nursery production, increasing regulatory agriculture requirements and more movement of plants come into focus, SANC will be a vital response to adequately meeting the pest challenges within a fiscally limited environment. It is becoming more evident that all the stakeholders must work together more closely to meet the expansion of the world market and yet adequately mitigate the plant pests and pathogen risks associated with plants.

DEFINITION of a CONCEPT: A systems approach strategy incorporates specific operational nursery practices that minimize the likelihood of incursion, establishment and growth of plant pests and pathogens in a nursery. A systems approach requires two or more measures that are independent of each other, and may include any number of measures that are dependent on each other. An advantage of the systems approach is flexibility in the ability to address variability and uncertainty by modifying the number and strength of measures to meet phytosanitary import requirements.

Cultural practices, crop treatment, post-harvest disinfestation, inspection and other procedures, to name a few, may be integrated in a systems approach. Risk management measures designed to prevent contamination or re-infestation are generally included in a systems approach (*e.g.*, maintaining the integrity of lots, requiring pest-proof packaging, screening packing areas). Likewise, procedures such as pest surveillance, trapping and sampling can also be components of a systems approach.

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Measures that do not kill pests or reduce their prevalence, but reduce their potential for entry or establishment (safeguards) can be included in a systems approach. Examples include designated harvest or shipping periods, restrictions on the maturity, color, hardness, or other condition of the commodity, the use of resistant hosts, and limited distribution or restricted use at the destination.

Dependent and Independent Measures

A systems approach may be composed of independent and dependent measures. By definition, a systems approach must have at least two independent measures. An independent measure may be composed of several dependent measures. With dependent measures the probability of failure is approximately additive. All dependent measures are needed for the system to be effective. If one measure fails, it too fails the other measure. For example, a pest-free glasshouse where both a double-door and screening of all openings is required is an example where dependent measures are combined to form an independent measure. If the probability that the screening fails is 0.1 (1 chance in 10), and the probability that the double doors fail is 0.1 then the probability that the glasshouse will be infested is the approximate sum of the two values, 0.2 (1 chance in 5). The probability that at least one of the measures fails is the sum of both probabilities minus the probability that both fail at the same time. In this example, the probability is 0.19 (0.1 + 0.1 − 0.01), since both the measures could fail at the same time. The failure of either measure directly influences the success or failure of the other measure and accounts for the little change in overall probability of failure in the nursery.

Where measures are independent of each other, both measures must fail for the system to fail. With independent measures, the probability of failure is the product of all the independent measures. For example, if the inspection of a shipment has a 0.2 probability of failure and the limiting of movement to certain areas through regulations has a 0.2 probability of failure, then the probability of the system failing would be 0.04 (0.2 × 0.2). From these examples, it becomes evident that independent measures can provide a much preferred lower level of potential failure of a system approach to mitigate a pest problem.

Utilizing a systems approach to nursery certification is focused on better confidence in the pest-free status of a nursery plant through the lowered risk of a plant pest introduction and reproduction. For the nursery grower it also can result in lesser need for chemical controls and lower costs, fewer losses to plant pests and greater productivity. Conversely, for the buyer the risk of purchasing an infested plant and establishing new infection foci in a new area is much reduced.

Utilizing a systems approach mitigates shortcomings of end-point inspections, *e.g.*, infected plants are symptomless, pesticides may be suppressing symptoms, signs or symptoms of infestation/infection may not be recognized, detection limit is too high.

ELEMENTS of a FRAMEWORK: A SANC for any nursery requires a framework built from several elements. These key elements include:

- Risk analysis of the nursery
- Critical control points identified at the nursery
- Development and implementation of appropriate best management practices as required by pest species or group

- Monitoring and recording of pests found on plants when received in the nursery and when plants are shipped
- Recording of actions at the nursery, including IPM practices, staff training and production methods
- Documenting the source, movement and buyers of plants, for incoming and outgoing plants to allow traceability (*i.e.,* trace forward or trace back if a plant problem becomes known).

Utilizing a SANC is focused on higher confidence in the pest-free status of a nursery plant through the lowered risk of a plant pest introduction and reproduction. For the nursery grower, a SANC can result in lesser need for chemical controls and lower costs, fewer losses to plant pests and greater productivity. Conversely, for the buyer the risk of purchasing an infested plant and establishing a new infection site in a new area is much reduced.

This paper will focus on the first three elements which form the essential framework of a systems approach to nursery certification.

<u>Hazards and Critical Control Points</u>

Hazard is the potential to cause harm; risk on the other hand is the likelihood of harm (in defined circumstances, and usually qualified by some statement of the severity of the harm). Plant pests can cause a hazard in a nursery by damaging plants as well as lead to restriction of sales or movement of the affected plants. A risk analysis is a systematic way of gathering, evaluating, and recording information leading to recommendations for a position or action in response to an identified hazard. Risk analysis of a nursery can be achieved through use of Hazard Analysis and Critical Control Points (HACCP). This strategy is a systematic preventive approach widely used in food and pharmaceutical safety that identifies physical, allergenic, chemical and biological hazards in production processes that can cause the finished product to be unsafe, and designs measurements to reduce these risks to a safe level. In this manner, HACCP is referred as the prevention of hazards rather than finished product inspection. A critical control point (CCP) is a point, step or procedure at which controls can be applied and a nursery pest hazard can be prevented, eliminated or reduced to acceptable (critical) levels. In food safety, the most common CCP is cooking, where food safety managers designate critical limits, *e.g.*, for poultry, minimum internal temperature is 165°F (74°C) for 15 seconds. In a nursery, it may be requiring that re-used containers must be sterilized with a specific concentration of a disinfectant between uses to ensure adequate kill of pathogens.

The application of a critical control point system for phytosanitary purposes may be useful to identify and evaluate hazards as well as the points in a pathway where risks can be reduced and monitored and adjustments made where necessary. The use of a critical control point system for phytosanitary purposes does not imply or prescribe that application of controls is necessary to all control points. However, critical control point systems only rely on specific independent procedures known as control points. These are addressed by risk management procedures whose contribution to the efficacy of the system can be measured and controlled.

Therefore, a systems approach for phytosanitary purposes may include components that do not need to be entirely consistent with the critical control point concept because they are considered to be important elements in a systems approach for phytosanitary purposes. For example, certain measures or conditions exist or are included to compensate for uncertainty. These may not be monitored as independent procedures (*e.g..* packhouse sorting), or may be monitored, but not controlled (*e.g*., host preference/susceptibility).

As a SANC is developed, it is useful to look at the seven principles of HACCP which form the basis of understanding and controlling the risks of pest hazards:

> **Principle 1: Conduct a hazard analysis.** Determine the nursery pest hazards and identify the preventive measures the nursery can apply to control these pest hazards. A nursery pest hazard is any biological, chemical, or physical property that may cause a nursery plant to not remain pest-free. There may be certain types of hazards in association with specific pests or types of pests which can vary from nursery to nursery.
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> **Principle 2: Identify critical control points.** A critical control point (CCP) is a point, step, or procedure in a nursery at which an independent control measure can be applied and, as a result, a pest hazard can be prevented, eliminated or reduced to an acceptable critical limit.
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> **Principle 3: Establish critical limits for each critical control point.** A critical limit is the maximum or minimum value to which a nursery pest hazard must be controlled at a critical control point to prevent, eliminate or reduce to an acceptable level.
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> **Principle 4: Establish critical control point monitoring requirements.** Monitoring activities are necessary to ensure that the process is under control at each critical control point.
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> **Principle 5: Establish corrective actions.** These are actions to be taken when monitoring indicates a deviation from an established critical limit. Corrective actions are intended to ensure that no nursery product injurious to other plants enters commerce.
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> **Principle 6: Establish procedures for ensuring the HACCP system is working as intended.** Verification ensures that the nurseries do what they were designed to do; that is, they are successful in ensuring the production of pest-free plants. Verification ensures the HACCP plan is adequate—it is working as intended. Verification procedures may include such activities as review of HACCP plans, CCP records and critical limits. Verification also includes 'validation' – the process of finding evidence for the accuracy of the HACCP system (*e.g.,* scientific evidence for critical limitations).
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> **Principle 7: Establish record keeping procedures.** The HACCP approach requires that all nurseries maintain certain documents, including its hazard analysis and written HACCP plan, and records documenting the monitoring of critical control

points, critical limits, verification activities and the handling of production deviations.

In terms of a nursery, we can refine and reduce this to a Critical Control Point System (CCPS). A critical control point system in a nursery would involve the following procedures:

1. Determine the pest hazards and the objectives for measures within a defined system
2. Identify independent procedures that can be monitored and controlled
3. Establish criteria or limits for the acceptance/failure of each independent control measure
4. Implement the system with monitoring as required for the desired level of confidence
5. Take corrective action when monitoring results indicate that criteria are not met
6. Review or test to validate system efficacy and confidence
7. Maintain adequate records and documentation.

Critical Control Points and Best Management Practices

Determining the hazards can start with a production flow chart of the nursery to form the hazard analysis. As an example, we can use *Phytophthora ramorum* as a known pest hazard. This is a pathogen moved by soil, water and infected plant material. In the case of a container nursery, procedures used in handling of potting media and containers, water, plant procurement and propagation and plant disease management are important to the survival and movement of the pathogen. Additional information would be needed on the site being used including its preparation and maintenance. Depending on the operation, greenhouse or field production areas, as well as cull piles, are where additional hazard analyses are warranted. Several critical control points and resulting independent control measures, *i.e.*, best management practices, have been identified (Table 1). From the identification of the CCPs, best management practices can be developed to constrain the hazard. A best management practice is a method or technique found to be the most effective and practical means in achieving an objective (such as preventing or minimizing a pest infestation) while making the optimum use of the nursery resources.

Table 1. Critical control points form the basis of best management practices for *Phytophthora ramorum*.

Critical Control Point	**Best Management Practice**
Placement of container plants on contaminated ground	Do not place containers on contaminated ground
Use of contaminated irrigation water	Treat irrigation water before use
Use of contaminated pots	Use new pots or properly disinfest used pots
Buy-ins of infected pots	Buy only from certified suppliers; quarantine plants for 90 days
Poor drainage	Prevent standing water
Accumulation of infested leafy debris	Prevent accumulation of infested leafy debris

As another example, the armored Euonymus scale damages deciduous and evergreen euonymus (*Euonymus* spp.), pachysandra (*Pachysandra* spp.) and bittersweet (*Celastrus* spp.). Vine-type euonymus are extremely susceptible to attack by this scale. Several independent control measures or best management practices can be utilized to limit this pest hazard in a nursery (Table 2).

Table 2**.** Critical control points form the basis of best management practices for the Euonymus scale.

Critical Control Point	**Best Management Practice**
Growing nursery plants near wild host plants	Remove wild host plants a minimum distance
Buy-ins of infested plants for grow-out	Buy only from certified suppliers; inspect and segregate plants into holding areas
Disposal of newly infested plant parts	Destroy cull pile material daily
Water stress	Manage water levels for thrifty growth and group plants with similar water needs
Equipment movement of pest	Clean equipment between production areas
Cultivar or species susceptibility	Use resistant cultivars or species

As has been illustrated, conducting a hazard analysis to delineate the pest hazards, identification of critical control points and resulting use of best management practices form the essential framework to a systems approach to nursery certification. Many best management practices that would result from a critical control point system are often already utilized, in whole or part, in current nursery operations.

Depending on the plant species and associated pests or diseases, a systems approach to nursery certification would include independent and dependent measures that can be broadly categorized into three best management practice types:

1. Pre-planting**:** Use healthy planting material, resistant or less susceptible cultivars, pest-free areas, pest-free places of production or pest-free production sites, producer registration and training.
2. Growing: Use field management procedures (*e.g.,* inspection, pre-harvest treatments, pesticides, biological control, *etc*.), protected conditions (*e.g.*, screen houses, greenhouses), pest mating disruption, cultural controls (*e.g.,* sanitation, weed control), low pest prevalence (continuous or at specific times), testing.
3. Pre-shipment: Use plants at a specific stage of development or time of year (*e.g.,* after deciduous leaves fall, juvenile or mature), sanitation (*e.g.,* removal of leaf litter), testing, treatment (*e.g.,* pesticide application, exclusion); inspection and grading (including selection for certain maturity or quality stages); sanitation (including removal of parts of the host plant); testing; screening of storage areas.

Once the hazard analyses are conducted, critical control points are identified and best management practices are developed, the remaining elements can be formulated for the SANC. These would include implementing the system with monitoring; taking corrective actions if so identified from monitoring; validating the system on a regular basis; and maintaining records and documentation. Even these steps may be found to be wholly or partially done in many nurseries, but have not been built into a structured systems approach *per se*.

Overall, a systems approach for nursery certification requires a methodical gathering of information pertinent to the pest hazards associated with a nursery followed by development and use of best management practices that can be documented and verified to demonstrate the successful performance of the systems approach. As often the case, the first step is the hardest, but once the journey is underway, the next steps are much easier.

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