TECHNICAL

NURSERY PAPERS

July 2015 Issue no.6

Nursery Production Pest Monitoring, Inspection and Surveillance Methodology

In 2013 NGIA commissioned a project to investigate statistically valid systems and protocols for on-farm monitoring, inspection and surveillance for pests of biosecurity concern within production nurseries. The project, completed in 2014, has investigated national and international information and systems and has developed recommended monitoring, inspection and surveillance protocols that have the highest probability of success. NGIQ Industry Development Manager John McDonald provides details in this Nursery Paper on the key project outcomes for use within production nurseries.

Nursery Production Pest Monitoring, Inspection and Surveillance Methodology

What is the key issue?

Despite numerous monitoring, inspection and surveillance protocols and systems developed both in Australia and abroad that provide guidance on implementing these programs, few investigate and provide an evaluation of the efficacy of what is proposed in a quantitative sense. This is understandable due to the complex and varied nature of the problem based on the thousands of cultivars grown across varied cropping systems (e.g. seedlings, small containers, advanced trees, etc.) and the exposure to a vast array of plant pests and diseases.

Nursery production is both unique and diverse, as are the numerous pests and diseases that can impact on the quality and economic return gained from the thousands of plant cultivars produced. Production can also be both intensive and extensive ranging from the production of plugs and seedlings to advanced tree stock and in-ground plant production.

In Australia, quantitative sampling systems that do exist fall primarily within the realm of inspection, treatment and certification for intra and interstate movement of plants that are hosts of specific and regulated plant pests and diseases. For example, approved inspection protocols for the movement of plants known to be hosts of melon thrips between infested and non-infested jurisdictions.

For visibly detectable pests and disease symptoms, the development, approval and agreement on inspection systems directed at meeting interstate movement regulations is generally consistent with systems used by national quarantine authorities. These systems are applied to host material to provide assurance that imported plant products are free of pests and diseases of concern to Australia. The team undertaking this nursery project have ensured the protocols recommend are quantitative in nature as this form of analysis is the basis for on-farm structured and knowledge based decision making that will deliver the best return on investment.

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For the purpose of this Nursery Paper, **'monitoring'** means the regular ongoing examination of a population of plants (e.g. crop monitoring) to determine changes in presence, incidence and or prevalence of pest populations. This can include ongoing physical examination of the plant and/or other methods such as trapping or regular diagnostic testing. 'Inspection' means the visual examination of a plant or group of plants to determine if a pest or disease symptom is present at one point in time e.g. consignment despatch inspection. **'Surveillance'** means the process of looking for potential plant pests across the whole production site, excluding the crop, such as areas of native or exotic vegetation, waterways, drainage lines and water storage areas, car parks, waste disposal areas, etc.

Why monitor, inspect and survey for plant pests?

There are three primary reasons why producers may monitor, inspect and survey for pests:

- To estimate pest population density, in order to make optimal pest management decisions, such as when to manage and what management measures to use (e.g. release beneficial's or treat with a pesticide). This includes decision making regarding management for optimal productivity and control for optimal quality for the market
- To provide assurance that general biosecurity obligations have been addressed and/or to facilitate market access for freedom of pests of quarantine concern
- To detect high risk exotic biosecurity pests (Emergency Plant Pests – EPP's) in order to respond effectively in accordance with legal reporting and industry obligations aimed at eradication

Visual monitoring, inspection and surveillance

Visual observation is a fundamental inspection, monitoring & surveillance method that should be used as a minimum and in combination with other detection methods, such as trapping or testing. In other words, other monitoring methods should always be supplemented/supported by visual inspection for pests, weeds and disease symptoms in a structured detection program.
Whole crop visual scanning may be undertaken initially to observe and map areas of uneven plant growth, colour/damage or obvious disorders such as wilting, etc. Individual plant observation is then conducted to explain any differences observed, that is take a sample and inspect/test to determine the causal agent. Finally if no obvious issues are observed at the time of crop scanning random sampling and inspection is undertaken to detect infestations not apparent through initial whole crop observation. Many to most insect species can be visually detected on the external surfaces of plants including stems, foliage, buds/flowers, and plant roots. Smaller invertebrate species may require magnification with a hand lens or microscope such as eriophyid mites. Disease symptoms, and some pathogen life stages (e.g. rust spore pustules), may be distinctive and after sampling may require sensitive testing, such as ELISA and/or PCR, or laboratory based isolation and culturing of the pathogen to provide confirmation of a specific infestation.

The sensitivity of visual inspection for identifying infestations can be poor if it is done carelessly, is rushed or by someone without experience. Approaching this task methodically (a structured and planned procedure) can increase its sensitivity (effectiveness) greatly. Methodical improvements can be made at different scales including the whole crop, individual plants, and parts of individual plants such as flowers and buds, leaves, stems and roots. Experience and plant protection knowledge will lead to improved sensitivity, but often even experienced staff could improve their detection sensitivity if they are methodical.

The approach for examining plants depends on the pests being sought. It may involve dislodging and capturing insect pests by beating onto trays, or inspecting insects more carefully in their feeding location if they are firmly attached or fly away readily, or inspecting leaves for symptoms, or taking leaf samples for analysis, or examining the roots for pests or symptoms.

Table 1. Inspection type and population to sample

Inspection type	Population of plants
Import inspection	All plants of the same species/type that are imported as a consignment.
Despatch inspection	All plants of the same species/type that make up a consignment.
Monitoring inspection	A lot or batch of the same species/type that may include plants grown on one or more blocks or benched areas within the same general location.
Sentinel plants	A lot or batch of the same species/type that may include plants grown on one or more blocks or benched areas within the same general location.
Sticky traps	All traps.
Site surveillance	The entire property, broken up into logical and manageable sub- areas.

Import and despatch inspection

For import and despatch plant inspection the report recommends that a default 50% sensitivity of detection be used. It is believed that this default sensitivity of detection is likely an underestimate of the true sensitivity of detection of pests (including their symptoms) plus it equates with the existing national quarantine protocol of 'inspect 600 units' irrespective of population size.

For import and despatch plant inspections the report has recommended that, at a minimum, an inspection be conducted to detect pest infestation, prevalence, at a maximum of 1% within the imported/despatched consignment. Therefore a maximum of 600 units will be sampled for import and despatch inspections with a minimum of 520 units sampled in smaller consignments. Table 2 contains the minimum sampling rates applicable to import/

despatch inspections.

Number of plants	Minimum number required to be inspected	Inspection rate
1 to 500	All	All
500 to 600	All	All
601 to 700	All	All
701 to 800	All	All
801 to 900	All	All
901 to 1000	520	61% (2 in 3 plants)
1001 to 1200	530	56% (3 in 5 plants)
1201 to 1700	550	48% (1 in 2 plants)
1701 to 2400	565	34% (2 in 5 plants)
2401 to 3000	570	25% (1 in 4 plants)
3001- 3600	575	20% (1 in 5 plants)
3601 - 4500	580	13% (1 in 9 plants)
4501 – 10,000	590	6% (1 in 16 plants)
>10,000	600	Calculate the percentage based on consignment total

Table 2. Import & despatch inspection sampling rate

Monitoring inspections

The report recommends when conducting a monitoring program across a production nursery for multiple pests and diseases (as is typically the case) the lowest actual estimated sensitivity of detection across all pests being surveyed should be used as the default – assuming an acceptable level of training is provided in the identification of pests and disease symptoms. For inspection regimes to be used within the scope of a monitoring program the report recommends an inspection cycle be undertaken to achieve a maximum design **prevalence of 5%** at the end of the cycle.

Designing a survey where we use the lowest realistic estimate of sensitivity is a conservative, risk-averse, approach. In this case the estimate of the likely lowest estimate of sensitivity of detection of target pests is 70%. The estimated sensitivity for the detection of common insects and disease symptoms are listed in Table 3 below plus results comparing end point inspection (1 inspection) and crop monitoring (12 crop monitoring activities).

The information in Table 3 is generated via a statistical modelling program which demonstrates that through the use of a methodical (structured) crop monitoring program over 12 weeks inspecting 35 plants per monitoring activity, out of a population of 10 000, the sensitivity is equal to an end point despatch inspection of 421 plants. The above example reflects the current national and state end point inspection protocol of 600 units for inspections.

Further analysis of the above data shows that after 1 inspection (aphids) the maximum prevalence of target pests if not detected initially, is 0.70% however after 12 weekly inspections the maximum pest prevalence, if not detected over the 12 inspections, is 0.05%. When the monitoring and end point inspections are combined the maximum number of potentially infested plants is 2 or 0.02%, well below our target prevalence figures of 1% for inspections and 5% for monitoring.

Monitoring frequency

Survey frequency for monitoring purposes should be governed by the life cycle of the target pest and for practicality. For example, pests with short life cycles that can grow and expand populations rapidly should be inspected more frequently because if they are missed during one inspection, and there is a long lag time until the next inspection, a significant amount of damage could have been done to the crop. However, surveying too frequently (e.g. daily) is costly, impractical and potentially unnecessary if a structured system is employed.

For practical purposes the report recommends **weekly monitoring** by allocating a set day during the week which is easily scheduled and should be considered as a routine task with results recorded. Inspecting every 7 days also fits into the shortest lifecycle periods under ideal circumstances by problem pests in most cropping systems.

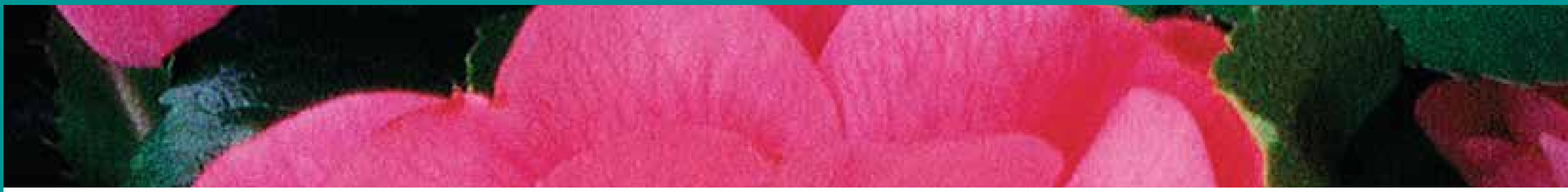
Monitoring sample unit

When surveying (inspecting) the crop a systematic approach to selecting sample units from the population for inspection is essential. If the survey program (crop monitoring) will run over a period of time (i.e. the nursery stock will be in the production nursery for many weeks and monitoring will take place weekly) the starting point for each weekly inspection should vary. For example, on the first monitoring week every 10th unit may be sampled starting from the 3rd plant in row 1, and on the second monitoring week every 10th unit may be sampled starting from the 5th plant in row 1, and so on. This ensures the same plants are not monitored

Table 3. Likely maximum prevalence of infested plants when the survey population is 10 000 plants and 600 plants are inspected at 95% confidence using estimated sensitivity of detection.

Pest/symptom	Estimated Method Sensitivity (Visual Inspection)	Maximum prevalence of infested plants if not detected after 1 inspection	Number of plants inspected to achieve 1% prevalence result with 1 inspection	Number of plants inspected to achieve 1% prevalence result with 12 crop monitoring activities
Aphids	70.00%	0.70%	421	35 plants/population
Caterpillars	90.00%	0.55%	328	27 plants/population
Mites	70.00%	0.70%	421	35 plants/population
Scales	80.00%	0.62%	369	31 plants/population
Whiteflies	80.00%	0.62%	369	31 plants/population
Botrytis symptoms	90.00%	0.55%	328	27 plants/population
Downy Mildew	90.00%	0.55%	328	27 plants/population
Phytophthora	90.00%	0.55%	328	27 plants/population
Weeds	99.00%	0.50%	298	25 plants/population
Rust symptoms	90.00%	0.55%	328	27 plants/population

Note: Survey interval is one week –
12 surveys = 12 x weekly monitoring activities



across each week and underpins the detection system sensitivity. The report has determined for crop monitoring within a production nursery the most statistically valid rate based on the recommended sensitivity and prevalence parameters is to inspect 30 plants within the monitored population. If 30 or less plants are in the monitored population, inspect all plants. Table 4 gives indicative numbers of plants to sample based on various crop populations.

Table 4. An indicative proportion of plants/rows to sample in a monitoring activity

Population and proportion to be examined		Number to sample	Population and proportion to be examined		Number to sample	Population and proportion to be examined		Number to sample
10	All	All	**100**	30.00%	1 in 3	**1000**	3.00%	1 in 33
20	All	All	**200**	15.00%	1 in 6	**2000**	1.50%	1 in 66
30	All	All	**300**	10.00%	1 in 10	**3000**	1.00%	1 in 100
40	75.0%	3 in 4	**400**	7.50%	1 in 13	**4000**	0.75%	1 in 133
50	60.0%	3 in 5	**500**	6.00%	1 in 16	**5000**	0.60%	1 in 166
60	50.0%	1 in 2	**600**	5.00%	1 in 20	**6000**	0.50%	1 in 200
70	42.9%	3 in 7	**700**	4.29%	1 in 23	**7000**	0.43%	1 in 233
80	37.5%	2 in 5	**800**	3.75%	1 in 26	**8000**	0.38%	1 in 266
90	33.3%	1 in 3	**900**	3.33%	1 in 30	**9000**	0.33%	1 in 300

The above recommended sampling numbers/frequencies are the minimum values recommended by the report. If sampling numbers/frequencies are increased, where more plants are inspected and/or inspection frequency is increased, then the greater the sensitivity of the process resulting in higher crop quality at the end of the cropping cycle and/or earlier detection of possible problem pests which will reduce the cost of corrective action. Through the use of on-farm skill sets in pest, disease and weed identification and the use of knowledge support tools, such as pest identification resources (see www.pestid.com.au), production nurseries can reduce the risk associated with pest infestations through inspection, monitoring and surveillance of the crop and production system.

References

Telford, G.A. & Potts J.M. (2014) A review and analysis of nursery production pest monitoring, inspection and surveillance methods. Report Number NGIA-260813-01 produced for the Nursery & Garden Industry Australia by Biosecurity Solutions Australia and The Analytical Edge Statistical Consulting.

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Published by NGIA, PO Box 7129 Baulkham Hills BC NSW 2153