TITLE: Creating an Integrated Pest Management (IPM) Program for the Marion Rivinus Rose Garden at the Morris Arboretum

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ABSTRACT:

This project seeks to catalogue the Integrated Pest Management (IPM) approaches practiced in rose gardens throughout the mid-Atlantic region of the U.S. and beyond. It will begin with a section explaining the history of IPM at Morris Arboretum and the theory and practices currently surrounding IPM in a public rose garden setting. Then, priority issues in the Morris Arboretum Rose Garden are examined one at a time by synthesizing research garnered from interviews with other rosarians and academic sources. This information will be interpreted, at the end of the paper, to suggest a renewed IPM program for the Morris Arboretum Rose Garden. Suggestions will include templates for establishing thresholds, keeping records, and early identification and treatment of issues.

Appendix A contains the survey tool I created to conduct the research for this project, with a list of all of the respondents. This network of gardeners and IPM specialists should be a future resource as we move forward with new approaches to managing pest and disease issues in the Morris rose garden. Appendix B contains a sample monitoring tool for recording rose performance, as well as threshold guidelines for fungal disease.

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INTRODUCTION

The goal of this project is to lay the groundwork of a formal integrated pest management (IPM) program for the Morris Arboretum Rose Garden. The research process started as an endeavor to objectively collect information from other rose gardeners and IPM specialists. I developed a survey as a guideline for the conversations; focusing on evaluation of major pest issues, control methods, and the selection process for disease-resistant roses. What I learned in my inquiries prompted me to think more critically about the particular aesthetic, ecological, and time-management considerations that need to be made before a true IPM program is even established. It was a chance to envision not just the selection of roses and treatments to keep them healthy – but also the evaluation, record-keeping, and process for careful observation of the collection in keeping with best pest management practices.

I based my approach to the investigation on the following components of a successful IPM program. I have italicized the portions that I felt were missing from our current approach:

1. Identification of pests and possible natural enemies.
2. *A monitoring and record keeping system for regular sampling* of pest and natural enemy populations. Monitoring is an ongoing activity.
3. Determination of injury level or that size of the pest population correlated with an injury sufficient to warrant treatment. In determining injury levels, the amount of aesthetic or economic damage that can be tolerated must be *correlated with the population size of pests, natural enemies, time in the season, and/or life stage of the pest or host*.
4. An integration of treatment methods that are effective against the pest, least disruptive to natural controls and least hazardous to human health and the environment.
5. *An evaluation system to determine outcome of treatment actions.*
6. These components are based on those drafted by the Bio-Integral Resource Center—a Berkeley, CA-based nonprofit advancing ecological IPM practices (Bio-Integral Resource Center 2015). They were used as benchmarks of success by similar researchers, notably Nancy Bechtol's work comparing IPM programs for the Longwood Graduate Program (Bechtol 1989). I observed all of these components in practice at Longwood Gardens, the Smithsonian, the New York Botanical Garden, and the United States Botanic Garden. They are the benchmarks of a successful IPM program that not only treats pests, but also determines performance patterns of plants and treatments at different times throughout the season.

BACKGROUND

Despite popular belief that disease and pest damage to roses is inevitable without broadcasted chemical applications on a regular basis throughout the season; roses do not need to be and **should not** be exempt from a carefully planned IPM program. Dr. Ann Rhoads, former Botany Director and Plant Clinic Supervisor at the Morris Arboretum, writes on the subject of IPM: "Plant selection, habitat modification and cultural practices that favor host vigor and

decrease susceptibility to pests are encouraged …When chemical controls are needed, the use of *highly specific, carefully timed and localized treatments* is preferred over the traditional cover spray approach" (1985) (emphasis added). This statement is extremely relevant to rose cultivation, yet it is quite common for rose gardeners to casually use highly toxic chemicals as part of their care regime without considering the many other options available to create optimal growth conditions in a much more ecologically considerate manner. These oversights can result in thousands of gallons of toxic chemicals needlessly sprayed each season.

Rather than automatically relying on chemical treatments, three other approaches must be considered *first*: mechanical, biological, and cultural control of pests. Mechanical control is any physical removal or prevention of the pest—such as building a higher fence, pulling weeds, or removing insects by hand. Biological management means attracting or releasing beneficial insects to be predators on unwanted species. Cultural control—perhaps the most important of the three—simply relies on the plant's immune system to protect itself from harm. Providing air circulation, hydration, and a balance of nutrients creates the conditions for optimal plant health, thus improving the rose's natural ability to fight off infection (P. Zimmerman, personal communication, 29 October 2014). If chemicals *are* required—and many times, unfortunately, they are—proper timing and selection of the most effective treatment at the lowest toxicity level is imperative. While some of these treatments methods are not applicable to specific pests, it is important to consider all of them whenever a pest management issue arises to pay due diligence to the possibilities for ecological management.

The Morris Arboretum Rose Garden has never been a part of the IPM program originally established for the rest of the gardens, under the leadership of Dr. Ann Rhoads, in 1981. Since then, the Plant Protection Intern has been hired to devote 20 hours per week to observation, record-keeping, and research in IPM. Because of roses' assumed dependence on chemical sprays, they were exempt from the detailed monitoring system established for all other cultivated areas and surrounding lands (Bechtol 1981).

Concern about the toxicity of traditional chemical treatments in the Rose Garden, however, has certainly been voiced by various gardeners over the years. Despite this concern, and perhaps in part because of turnover in the role of rosarian, a formal evaluation system has not been developed to track the performance of different varieties of garden roses under various spray conditions. Yet a formal evaluation system is necessary to alleviate the risk of trying new roses in a garden with demanding aesthetic expectations. This approach is at the very heart of IPM. It is the key to planting the right roses for particular microclimates within the Rose Garden, optimizing performance and beauty, and responding appropriately when some roses fail.

Beyond the ecological, human health, and economic impact, a disorganized approach to pest management can incur; laws governing chemical sprays in public gardens and parks are shifting to mandate only low-toxicity chemical spraying. The data from this project is a preemptive move to envision a program in compliance with possible future adjustments to chemical spray governance in the public garden sphere. My hope is that the research engenders a more nuanced approach to pest management in public rose gardens, which is clearly in the best interest of the management, staff, and guests of this institution.

METHODS

I visited or spoke with representatives from a variety of gardens and institutions, all of which have or are affiliated with prominent rose collections. While some are more applicable than others in terms of climate, location, garden style, etc.; all provided valuable insights to the project. A copy of the interview questions I used to glean this information, as well as a list of the gardeners and IPM specialists, with whom I spoke, are provided in Appendix A.

I have divided the research analysis into parts based on IPM priorities in the Rose Garden. Issues determined to be the most important to address include rose midge, rose rosette disease, deer browsing, black spot, and curation. Insights from interviews will be included in a summary of take-away messages and suggestions for improved treatment, supplemented by academic research where necessary.

ANALYSIS

Rose Midge *(Dasineura rhodophaga)*

Rose midge undergoes a typical fly lifecycle: maggots emerge from eggs laid between leaves and under sepals, then fall to the ground to pupate under the first inch or two of soil below. After pupating, the adult midge crawls or flies short distances (up to 100 feet) to the nearest rose cane, then burrows through the tip of the bud-shoot, where it lays its eggs (Shetlar 2011). At this point, one may observe a tiny black spot at the shoot tip, indicating where the midge has burrowed—but not always. Once the eggs hatch, the larvae feast on the fragrant bud forming inside the stem before dropping to the ground to start their lifecycle over again. This entire process occurs within a span of 5-7 days. At the end of the season, the last generation of larvae overwinters under the first few inches of mulch (Fetzer 2004).

Dasineura rhodophaga can be treated with highly specific, impeccably timed chemical treatments, careful mechanical control, and possibly with biological predators (Fetzer, J., personal communication, 21 January 2015; Piper, T., personal communication, 20 February 2015). This pest may be imported into the garden accidentally from nurseries—usually in the midge's pupal stage in the soil, where it is almost impossible to detect. Buying roses bare root or rinsing the soil from the roots of potted roses may prevent the midge from accidentally spreading (Rosetta 2014).

Midge damage destroys rose blooms before the buds even emerge. Damaged growth tips, or "blind shoots," may result in shriveled growth; crooked shoot leaves (whose petioles point downward rather than upward and outward); and crisp-looking, blackened sepals surrounding the missing bud (Fetzer, J., personal communication; Mayhew 2006). If the sepals are blackened, the midges have already dropped to the soil in order to begin their next lifecycle. However, in many instances the shoot leaves remain green, and the *only observable symptom* of this pest is a slight crook in the shoot leaf (Fetzer, J., personal communication). Because an infestation of midge can significantly delay or prevent blooms in the rose garden, it is important to use this pests' unique lifecycle to anticipate its behavior and prevent damage before the overwintering larvae pupate and emerge from the soil.

Chemical treatment

If a pesticide application is timed impeccably at the beginning of the growing season, before the midge emerges from the soil for the first time, it is possible to prevent the entire population with a single soil-based application. This is known as a "pre-emergent" spray (Gabel, D., personal communication, 4 November 2014; Fetzer, J., personal communication). A rule of thumb when managing for this pest is to assume that if shoot growth is starting, midge *could* be present—especially if there has been a population of midge in the past. Experts recommend timing the drench by measuring both the temperature of the soil and the amount of new growth on the roses.

The ideal soil temperature should measure 42-44º F, and should coincide with 1-2 inches of new leaf growth present for chemicals with a 1-2 week uptake time (Gabel, D. 2014, personal communication; Davis, G. 2014, 11 November 2014, personal communication). Soil temperature should be monitored daily during early spring to target midge. Gardeners can extrapolate temperature data from New Jersey Statewide Soil Temperature Map to the Philadelphia region (http://www.njweather.org/maps/nj-statewide-soil-temperatures). For chemicals with an uptake time of only a few days, target the drench to coincide with the first sign that bud growth is pushing—typically when the soil is around 55º F (Fetzer, J. 2014, personal communication).

Depending on the needs of the garden, a liquid imidacloprid drench was recommended over the granular application, as the liquid drench tends to have a higher rate of absorption (Fetzer, J. 2014, personal communication). If a liquid drench is applied, the gardener may also use the time as an opportunity to combine nitrogen fertilizer, or any fertilizer he or she chooses, to encourage healthy growth at the beginning of the season (Fetzer, J. 2014, personal communication). It is also important to note that imidacloprid greatly increases the fecundity of mites; at Brookside Gardens, horticulturists released predatory mites to control harmful ones after any imidacloprid drenching (Fetzer, J. 2014, personal communication).

If, for some reason, the gardener is unable to target the midge before it emerges for the season, bi-weekly foliar sprays can be regularly applied. The biweekly foliar spray option should be avoided if possible, as it has the same effect as the soil drench but mandates far more chemical spraying. Research indicates that a single pre-emergent soil application of imidacloprid (Merit) granules, compared with a biweekly foliar cyfluthrin (Tempo) spray applied from spring to fall, had the same efficacy—both reducing damage to 2% (Rosetta, R. & McNeilan, J. 2005). Biweekly foliar spraying should *only be used as a last resort*, or if for some reason midge has been detected in the garden *after* the preventative soil drench.

Targeted soil applications are also safer than foliar sprays because the chemicals are less likely to drift on to non-target plants. With any of these chemical applications, it is very important to time them when bees are not foraging—either very early in the morning, or in the evening. All chemically-based insecticides are highly toxic to bees, and some to aquatic invertebrates and fish. For Arboretum staff, I've listed the various chemicals used to control midge, organized by toxicity level, on the server under Horticulture →Rose Garden→IPM. As stated, in all of these cases, the less spraying, the better—and the less toxic the spray chosen, the better. Minimizing risk to the web of life and to ourselves while meeting the aesthetic and economic needs of the garden is our goal. How we experiment with various strategies will

depend on what we feel our risk threshold is that year. For years when we can afford to experiment with new strategies, there are a variety of organic approaches to controlling midge. Many of them can be combined with a chemical approach in order to create a healthier ecosystem in the garden. The key will be finding the right balance of treatments for our particular microclimate, which will take time, willingness to try new things, and careful monitoring.

Mechanical Control

Completely replacing the mulch in every bed during early spring is one chemical-free strategy that can physically remove the pre-emergent larvae still pupating in the soil. These insects don't burrow deeply, and can be removed by raking away and replacing the first inch or two of mulch. To save time, the gardener can perform this task at the end of spring pruning, as he or she will already be raking debris from the beds. Replace the mulch with a thick layer—three to five inches—as evidence indicates that any remaining pupated larvae do not have the stamina to crawl through such a thick layer to reach the roses (Fetzer, J. 2014, personal communication). If one were to try a less synthetic approach to controlling this pest, now would also be the time to apply azadirachtin, or neem oil, a popular bio-insecticide used successfully to control midge at the Brooklyn Botanic Garden (Owens, S., 10 October 2014, personal communication).

While Don Gabel, the IPM coordinator at New York Botanical Garden, insisted that neem oil does *not* work to control midge without an extremely favorable microclimate, it is interesting to note that gardeners have divergent opinions about this (2014, personal communication). We will see how this strategy works in New Jersey's Van der Goot garden, where rosarian, Shauna Moore, plans to switch from chemical controls to neem applications over the next few seasons (Moore, S. 13 October 2014, personal communication).

Midge population can also be significantly reduced by pruning out infested shoots. This is not only a treatment strategy that uses an organic approach, but is also an important follow-up precaution after a preventative drench. Carefully scouting the roses on a weekly basis is recommended (Fetzer, J. 2014, personal communication). Look for damage by observing shoot leaves– they will still be green, but will have a slight crook in them. It is sometimes possible to observe black, deadened tissue on the stem-tip of the canes—but again, if this is the case, the midges have already fallen to the soil to pupate (Fetzer, J.2014, personal communication). Put the shoots in a trash bag, secure the bag, and do *not* compost.

Pruning of infested shoots can be very effective because of the midge's considerable fecundity—over 35 larvae can emerge from a single bud! If each of those larvae reproduced 35 *more* larvae, you would have over 1,000 midges from just one overlooked shoot. And while scouting will never be perfect, as a general rule, the more damaged shoots pruned out of the collection, the healthier the roses will be. At New York Botanical Garden, gardeners purposefully deadhead roses 6-8 weeks before an important event in order to hone in on midge populations at this time. This strategy ensures that they are able to observe buds as they form in the stem and carefully monitor for midge. It also guarantees that roses will be blooming fully at the exact time a breathtaking bloom is required, during the important event for which they are planning.

Biological Control

Stephen Scanniello, curator of the Cranford Rose Garden at Brooklyn Botanic Garden, recommended *Hydronmermis conopophaga* as a beneficial parasitic nematode that targets rose midge (Scanniello 2006).These nematodes target insects with a fly life-cycle, invading their bodies during the pupal stage in the soil. While this specific nematode does not seem to currently be available from insectories, there are other nematodes that perform the same function, notably *S. feltiae* or the more cold tolerant *S. carpocapsae*. Teresa Piper, rosarian at Andalusia Garden, will be trying nematodes for midge this spring. She also mentioned that the nematode species *Heterorhabditis bacteriophora* can be predators of Japanese beetle grubs, another troublesome insect pest of roses (Piper T., 20 February 2015, personal communication). She recommends Rincon-Vitova Insectaries in California as a reliable supplier of nematodes and other beneficials (rinconvitova.com).

Rose Rosette Disease

Rose Rosette Disease (RRD) is among the most notorious disease obstacles faced by rose gardeners. RRD is actually a viral infection spread by an eriophyid mite, and vectored by the multiflora rose. In the early 1900s, the Asian multiflora rose was a common garden and landscape shrub. During the dust bowl of the 30s, the USDA recommended mass plantings of multiflora rose as soil stabilizers and natural fences across the Midwestern landscape. The plan backfired as multiflora roses began colonizing American forests as an invasive exotic. Today, multiflora rose is also the most popular vector of RRD, a disease often travelling undetected in the commercial rose industry. Evidence demonstrates that RRD targets roses with Asian parentage, like the multiflora rose, as well as most modern repeat-blooming roses. Particularly vulnerable are roses with already constricted growth, such as drift roses, possibly due to poor air circulation. The popular "knock out" shrub rose is also particularly susceptible, with some experts theorizing that knockouts are secondary vectors of the virus (there is no scientific evidence confirming this theory).

Across the board, all gardeners I spoke with respond to RRD the same way: immediate removal and disposal of the affected rose. To the extent possible, gardeners should attempt to dig out any root fragments still in the soil, and carefully dispose of any vegetative remains of the rose in the trash—*not* the compost pile. Afterward, it is recommended that the gardener shower and wash their clothes (Fetzer, J. 2014, personal communication). While debate exists as to how long gardeners should disinfect their pruners after contact with RRD-infected plants, experts insist that no cleansing is needed because contaminated pruners spread bacterial infections, not viral infections. Anecdotal evidence also speculates that the disease persists in the soil even after plants are removed. While academic evidence does not confirm this theory, many public gardens plant affected beds with perennials for at least a season.

Until further research is conducted, no controls for the RRD virus are known beyond measures of precaution. Careful monitoring should be met with immediate action if RRD is suspected. Symptoms include abnormally red, congested growth resembling a witch's broom; excessive size and quantity of prickles (thorns); swollen new growth that is thicker than old growth; and significantly stunted and distorted leaves. Eventually, the virus will progress to

excessive defoliation and dieback (Olson, J. & Rebek, E. 2014). In the past two years, we've lost about fifteen roses to RRD—around twelve in 2013, and three in 2014.

Some evidence suggests that roses without Asian parentage are less susceptible, and possibly resistant, to RRD. Particularly promising are native North American roses, such as *Rosa palustris* or *Rosa virginiana.* Efforts from emerging rose breeders seek to combine the RRD resistance and considerable vigor of North American species roses with the repeat-bloom and double-bloom traits of other rose classes. The hope is to breed RRD resistant roses with many of the desirable garden characteristics of other, more susceptible groups, like polyanthas or hybrid teas; to produce new, resistant roses with repeat blooms. Roses deemed to be more RRD resistant will be discussed in the list of disease-resistant roses in Appendix B: rose selection and evaluation.

Deer Browsing

Deer are a significant and costly issue for public gardens, especially in urban and suburban areas where food can be scarce. When deer enter the Rose Garden through failures in the surrounding fence, they eat not only buds and blooms of roses, but also the other perennials and annuals that add beauty to the garden. Chronic browsing has a huge impact on roses, stunting their growth and preventing them from achieving proper size from season to season. This kind of damage results in roses that are so small that they are difficult for visitors to find, even when they are in full bloom. It is important not to underestimate the impact that deer have on the garden. Every time a deer eats a rose bud, it means that all of the time, planning, and money spent on other pest controls has been wasted.

This issue is frustrating to garden staff because even deer repellant and the mesh fence we currently use to control deer do not keep the deer out of the garden. It is difficult to coordinate between section leaders and the facilities team how and when to close the gates. Where deer have been a problem in other gardens, I've seen ten foot metal fencing with simple hinged gates keep deer out. In the short term, garden staff can diligently search for where the mesh fence has been compromised over the years and try to make repairs—although that should probably be a job for the facilities staff. But in the long term, a more reliable fence is an investment worthy of a garden in which so many donors have invested and so many visitors have loved.

Black Spot (*Diplocarpon rosae)*

Black spot, a fungal disease, is perhaps the most well-known of garden rose maladies. Black spot weakens roses' immune systems and, over time, can cause defoliation and death. The *Diplocarpon rosae* fungus causing this disease thrives in moist, cool, humid conditions and festers in any leaf litter or debris in the rose beds.

Chemical treatment

Typically, black spot is treated with regular preventative fungicide sprays. Both organic and chemical fungicide treatments are available. Black spot is a persistent disease, however, and

quickly forms resistance to regular spraying of one class of chemicals. It is very important for gardeners to rotate among several chemical classes when planning a spray regime for roses. For employees at Morris Arboretum, popular fungicides are listed by class and toxicity level under the IPM tab of the Rose Garden folder, with samples of rotations used by other gardeners in the region.

Mechanical and cultural controls

Sanitary conditions in the garden are important to prevent black spot. It is good practice to continually rake or blow debris out of the beds to minimize the constricted environments where *Diplocarpon rosae* may fester. Pruning roses to thin out congested growth encourages improved air circulation, another method of prevention. Plant new roses with enough spacing to ensure they will not become crowded as they grow. The same goes for installing annuals and perennials as companion plantings—if they begin to compete for space with the roses, prune them back or remove them. The key here is lots of room for air to move around roses and clean beds with no trace of debris or litter—both proven methods for preventing black spot.

For these reasons, a properly managed rose garden cannot rely on the natural decomposition of leaf litter to rejuvenate the soil. Fallen leaves must always be removed, yet the soil still requires nutrients. To solve this catch-22, successful rose gardens wisely prioritize careful stewardship of soil, adding rich, organic, well-composted material at least once a season. Chemical fertilizers do not replace the trace nutrients brought to the soil by natural decomposition of organic material—as renowned rosarian Paul Zimmerman states; soil in the rose garden should emulate that of the forest floor (personal communication, 2014). In fact, when I asked those I interviewed for the number one cultural practice for healthy roses, the use of composted manure was the answer given by over half of respondents. This refrain is echoed by historic rose experts like Graham Stuart Thomas, who recommends mixing well-rotted compost to a depth of two feet every season, especially when planting new roses. Adding organic material also helps to create better soil structure by encouraging good drainage in areas of the garden impacted by compaction (Jimerson 1993).

Many public rose gardens buy their compost if they do not have adequate facilities onsite to make satisfactory material. Hershey Gardens dedicates $15,000 per season to buying compost since switching from their onsite product, due to issues of controlling weed seeds and other undesirables in their compost (Schiffer, J., 2014, personal communication). Andalusia garden applies compost tea mixed with worm castings to rose beds on a monthly basis. The worm castings are obtained from the Bucks County Worm Casting Company, and provide an alternative, organic source of nourishment for the roses (Piper, T., 2015, personal communication).

Rose selection and evaluation

Beyond cultural practices, a most important practice for preventing black spot is to plant the right rose in the right spot in the garden. For example, if a section of the garden has regularly moist, slowly draining soil and cool air, the gardener may be wise to select a hardier species rose like *Rosa palustris*, the Swamp rose; rather than a delicate hybrid tea. Following organic rose trials such as Earth Kind, ADR, and Biltmore International can help narrow down what roses

grow best in particular soil types without fungicide spraying. These trials release top performing roses that have been grown for at least a season without any chemical treatments. A list of blackspot resistant roses for our climate is listed in Appendix B: rose selection and evaluation.

Chosen roses should also be evaluated for their appropriateness to the microclimate of our garden. In a way, this process is similar to trialing, but specific to our garden roses' blackspot resistance and overall performance. Evaluations are important to the selection of roses at such notable public gardens as the U.S. Botanic Garden, NYBG, and the Scott Arboretum. Careful record-keeping is key to this process. Simple evaluation sheets filled out twice a year, tracking black spot defoliation of each rose in the garden, are a relatively easy way to record rose performance. These sheets can then be transferred to a larger spreadsheet tracking roses' performance over longer periods of time. I based ours on the one used by USBG to determine which roses to keep and which do not measure up to their standards. This kind of record keeping and evaluation system helps us to make informed decisions when designing the garden or renovating existing beds.

Evaluations are to be targeted to the two times in the season when the roses are under the most scrutiny: the Moonlight and Roses event, and the autumn bloom period. Groups of volunteers will be recruited from the Philadelphia Rose Society and trustworthy friends of the Arboretum will be asked to assist in performing these evaluations. The hope is that with the same participants evaluating the same roses from year to year, we will have accurate results from the evaluation. The evaluation works by assigning a score for rose health governed by percentage of observed defoliation. Beyond providing the evaluation sheets, we will provide benchmarks or examples of what a certain score—say 50% defoliated or 75% defoliated—will look like to guide participants' responses. Sample evaluation tools are provided in Appendix B.

DISCUSSION

The impending redesign of each quadrant of the Rose Garden over the next several seasons is both a challenge and an opportunity. Now is the time to implement careful planning and record-keeping measures to track how new roses perform from season to season. To supplement my research project, I will be working with plant recorder Elinor Goff this spring to map the roses currently in the garden to provide the basis for future decision-making and evaluation. I hope that all of these measures will create a level of continuity in the care of the roses in the garden.

Past experience has indicated that this sort of continuity is needed in our approach to growing roses. Novel approaches to rose care by former Arboretum rosarians—from Mike Tuszynski's technique of double-digging the beds and adding aged manure, to Justin Jackson's experimentation with compost tea trials, have made a considerable impact on the garden. Yet rather than becoming rose garden traditions, these techniques are relegated to wistful memories of past success whenever a staff change affects the garden's management. Jackson's 2012 intern, Prima Hutabarat, recommended *years* of dedication to an organic care regime to determine how specific IPM strategies like compost tea applications will impact the garden. Without an evaluation system for the roses and an IPM program in place that stays consistent

from year to year, even the best intentions will be lost in the shift and shuffle of staff and the pressures of managing such an intensive space.

Should we ever hope to switch to a more organic approach to gardening, we should expect at least five years until the soil biota begins to normalize enough to bring performance levels up to where they were under a chemical regime. Gardeners like Sarah Owens, Teresa Piper, Shauna Moore, and others are taking the steps to make this transition despite the initial aesthetic cost. Like any switch away from a less sustainable status-quo, it will take time for the investment to make a return—but the return will guarantee the longevity and health of the ecosystem of which our garden is a part.

ACKNOWLEDGEMENTS

I hope that the network of gardeners I've put together for this project will be a future resource not only to future employees of the Morris Arboretum, but also to each other. This project has taught me the importance of networking to solve common challenges, find support, and gain inspiration. Managing a rose garden is a difficult job with so many pressures and considerations. I admire anyone who is willing to take on the task, especially those who are willing to take real risks to try something they believe is the right thing to do. Thank you to each of you who took the time to respond to my survey and/or give me a tour of your beautiful gardens.

I would also like to thank Lucy Dinsmore for her ever-present advice, for spending hours helping edit and review my drafts, and for connecting me to other gardeners. Thank you to Vince Marrocco for discussing rose selection and evaluation, sharing valuable knowledge about pesticide use, and suggesting ideas about how to actually apply my project in real-time this season. The best feeling for an intern is knowing her research is actually having a positive impact on the garden, and I appreciate that you are willing to collaborate with me on the future of the garden. Thank you, also, to Tony Aiello, who suggested this project topic to me—it has become a very rewarding part of my internship experience. Finally, thank you to all future interns, volunteers, and staff members who take the time to read this project to search for answers to help the rose garden perform better.

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APPENDIX A: SURVEY TOOL AND RESPONDENTS

IPM Survey for Rose Collections

Hi gardeners and IPM specialists! I hope these questions will help guide my inquiry into best practices for rose garden management. They are divided into four sections: *Evaluation, Control Methods, Rose Health/Culture,* and *Selection*. If the question doesn't apply to your garden, please feel free to skip it. Any other information you think may be helpful is welcome and appreciated. Thank you for taking the time out of your day to do this!

Evaluation

1. What are the major pest problems and diseases affecting your collection?

2. How often do you scout for problems? Do you follow a monitoring schedule or have a record keeping system for your observations – i.e. a pest management calendar?

3. What kind of evaluation system do you have in place to measure the success of your treatments?
    a. Do you have ongoing mini-trials to compare different treatments within your collection?
    b. How often do you experiment with new management routines?

Control Methods

1. What preventative measures do you take to minimize pest populations at important stages in their life cycles (i.e. midge control)?

2. What chemical applications do you use on your roses? When do you start the spraying, and how often?
   related questions to consider:
    a. If you use organic fungicides such as CEASE or Greencure, do you alternate them with other controls?
    b. Do you have any organic recipes for fungicides, herbicides or pesticides that you'd like to share?

3. How do you keep deer out of your garden?

4. Do you have any success stories in terms of weed suppression and control? Any go-to methods?

5. What is your protocol for rose rosette disease?

Selection

1. What kind of roses do you find to be the most disease/pest resistant?
   Are there any too sensitive for chemical spraying?

2. When do you decide 'enough is enough' with a rose and decide to replace it with a better variety? What informs your decisions about rose selection in this scenario?

Rose Health and Culture

1. How do you care for your soil? Do you add mulch? Compost? Compost tea? Rotted manure?

    a. When do you add amendments and how much do you add?

    b. If you do not have a large-scale composting program on-site, have you developed outside partnerships to obtain compost?

2. In your experience, what have been the most important overall care practices for your roses in preventing disease and pest infestation (i.e. sanitation practices, air circulation, etc)?

3. If you have perennials, annuals, and/or bulbs in your rose garden, do you have any recommendations for best companion plantings? What are your favorite low-maintenance additions that don't crowd out the roses or constrict air circulation?

4. Have you tried any less conventional approaches to preventing issues—like introducing biological predators, adding nematodes or Mycorrhizae applications, etc.?

Respondents:

Andalusia Garden – Bucks County, PA..... Teresa Piper, Rosarian

Biltmore International Rose Trials – Asheville, NC..... Paul Zimmerman, Director of Trials

Brooklyn Botanic Garden – Brooklyn, NY ..... Sarah Owens, Rosarian and Curator

Brookside Gardens – Silver Spring, MD ..... Roger Haynes, Horticulturist II and Jody Fetzer, IPM Specialist

Hershey Gardens – Hershey, PA ..... Jamie Schiffer, Grounds Manager

New York Botanical Gardens – Bronx, NY ..... Don Gabel, IPM Manager

Rudolf W. Van der Goot Gardens– Somerset, NJ ..... Shauna Moore, Rosarian

USDA Natural Resources Conservation Service ..... Graham Davis, Plant Materials Center

Wyck House – Philadelphia, PA..... Denise Forrester, Rosarian

APPENDIX B: SELECTION AND EVALUATION

ROSE SELECTION

Roses regularly recommended by survey respondents included:

Old garden roses (OGRs)/Antiques – especially Rugosa roses, which do not need to be sprayed nor will tolerate spray.

Species (wild) roses – including *R. virginiana, R. palustris, R. sericea pteracantha,* etc.

'Bonica,' 'Home Run,' 'Carefree Wonder,' and other shrub roses

Roses from the breeder German breeder Kordes were repeatedly recommended for resilience and beauty

To select hybrid teas or other sensitive roses, consult winners of rigorous no-spray trials like the German ADR trial

Roses without Asian parentage are known to be resistant to Rose Rosette Disease (RRD). The only known class of roses *without* Asian parentage but that still have repeated blooms are the Damask Perpetuals, or Portlands. I've included resources in the references section for readers to learn more about this class.

Examples include 'Rose du Roi' (widely seen as the first Damask Perpetual),'Joasine Haret' aka 'Portland from Glendora,' 'Julie de Krudner,' 'Celine Dubos,' 'Aimee Vibert,' 'Bernard,' and more.

For the most part, this class does well in cooler climates. However, the following were found to be successful in zone 10:

'Paul Neyron', 'La Reine', 'Anna de Diesbach', 'Baronne Prévost', 'Mrs. R. G. Sharman-Crawford', 'James Bougault', 'Gloire Lyonnaise', 'Mme Verdier', 'Comtesse Cécile de Chabrillant' and 'Gloire de Ducher.'

As a whole, these roses are very cold-hardy, but do not like to be boxed into mixed borders—they need a lot of breathing room. They also don't mind afternoon shade, so they would be good candidates for the knockout quadrant.

Morris Arboretum of the University of Pennsylvania
Official arboretum of the Commonwealth of Pennsylvania

ROSE GARDEN BLACK SPOT EVALUATIONS

EVALUATOR:_____
DATE:_____

Bed	Variety	Base Rating 0-6	Blooming up to +3 pts	Total	Notes

Base Rating:
6 Healthy foliage, nice growth habit/good landscape value
5 10% leaf drop
4 25% leaf drop
3 50% leaf drop
2 75% leaf drop
1 90% leaf drop

Blooming/Landscape value add:
up to +1 Healthy foliage, only a *few* blossoms, nice growth habit
up to +2 Healthy foliage, a *significant* number of blossoms, nice growth habit
up to +3 Very healthy foliage, an *abundance* of blossoms, really nice growth habit
(points can be in fractions: i.e. ½, 1.75. 2.3)

This is a sample evaluation form.

Please find it on the server under Horticulture → Rose Garden → IPM Program.