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Building an Integrated Pest Management Plan for a Unique Urban Farming Program

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By: Jeff Coco

Introduction

The summer of 2018 led to an opportunity with a local non-profit called Fleet Farming. This non-profit had different departments available for internships which included greenhouse and farming. I was familiar with the program in that I knew they farmed in people's front yards, in 'farmlettes' that had been converted from lawns. I was most interested in the job description under farming that said "practicing IPM". I had developed an interest in IPM when I took Dr. Tom Weissling's class on the Management of horticultural crop insects in the Spring of 2018. I wanted more 'hands on' learning and this seemed like the perfect opportunity. I had very little IPM knowledge from previous classes at the University of Florida because, at the time, I had no interest in that path. This would change with my desire to learn and the opportunity presented to me.

Fleet Farming is an urban agriculture program that is funded by a non-profit called Ideas for us which spurs community involvement in a variety of environmental awareness projects. Fleet Farming has two underlining goals: (1) practice sustainable

farming while educating the community in these sustainable farming practices and (2) provide food to impoverished areas in the community. There are two branches of Fleet farming with multiple departments. The West Orlando branch is in the west side of downtown Orlando, in the Parramore district. Parramore is consider a "food desert" because of the lack of fresh, local food available to the inhabitants of the neighborhoods. We farm at this branch, at our headquarters, which is a church at Kaley square.

The Audubon branch, the branch that I manage, is the 'flagship' of Fleet Farming and contains 14 micro farms (farmlettes) in a neighborhood called Audubon Park. Most of the 'farmlettes' are residential properties that have been converted from lawns. A single property is commercial, at East End Market, with raised beds and serves a teaching site.

Fleet Farming is unique beyond the traditional urban farm concept. The Audubon Park branch is in a small neighborhood nestled in the northeast of downtown Orlando. The 14 'farmlettes' that I maintain are roughly within a two-mile radius of each other. All properties are maintained by a bike that hauls a trailer. (see Figure 1) We use this to haul tools, compost, plant starts, and any other items we need. It is not unusual to see a "fleet" of bicycles rolling down the street when we are out farming. Most of our labor is dependent upon volunteers and the interns we employ throughout each school semester.

Figure 1: Fleet Farming prototype bike and trailer Photo credit: Jeff Coco

Farming Practices

Many of our farming practices have been adjusted and most likely will be adjusted in the future as we continue to explore our methods.

Fleet Farming is an organic farming system. Because I work in the Audubon Park branch, I will specifically address what the practices are for these farmlettes. All plots are polycultures comprising up to 5-10 different crop species, depending upon space. Each semester the plots get compost from a local mushroom farm to amend the rows. This compost is composed primarily of horse manure and hay. It has great moisture retention and plenty of nutrients to give the plants a healthy start.

In between crops, we practice a crop rotation dependent upon what is growing that season. Usually we follow from cover crop, which is typically cow pea, then greens, to roots, and specialties such as tomatoes or peppers. Most crop residue that is not

diseased or infested with pests becomes ‘green manure’ and is chopped into the soil. Excess residues are composted on site.

Currently we are reworking our greenhouse potting mix to supply granular fertilizers into the soil. The concept is to build healthy soil for the plant starts and when transplanted the slow release amendments with be applied to the soil. Currently we don’t have the budget to apply amendments directly to the soil. All fruiting plants received liquid fertilizer throughout their growing stages. The infrastructure for growing healthy plants is in place and this is an important aspect of an integrated pest management plan.

Project Intent

The idea for this project was conceived from necessity and future potential impacts.

1. *Fleet Farming had no pest management protocols. The need for a program presented itself when I was an intern, as I was recording the different pest species that were present on the crops.*

   As an intern that was eager to learn ‘hands-on’ integrated pest management, I was disappointed to find out that there was no plan or protocols in place for pest management. I remember seeing other interns toting a sprayer full of unmeasured

Neem oil with the intent of spraying some aphids. Shortly after, I began recording all the insect pests I was seeing on the plots. I developed a spread sheet to keep track of the pests for each individual plot. I recently made and updated one for this upcoming year. Adjustments to last summer's plan has aided in the growth of the IPM program.

2. *Urban Farming is a unique system that could benefit from conversations and research pertaining to IPM in small scale, organic systems located within urban areas. Urban Farming could be the future of farming as current monoculture systems are unsustainable*.

IPM research pertaining to small, urban farms is lacking (Grasswitz 2019). Urban farming is a current trend but traditionally not a new method of farming. Urban agriculture has been steadily increasing over that last 30 years (Altieri 2019). When researching some methods of control or tactics, I found that I had to tread the line between home gardening practices and commercial farming practices. Commercial farming leans to the monoculture method of growing and is not a balanced ecosystem. Therefore, not a practical model to base my program on. It is my hope that dialog continues to develop that pertains to the ideas brought forth by Zalucki et al. (2014) and Peterson et al (2018) in redefining the principles of IPM which focus

on the entirety of the agroecosystem and not the pest in question. The latter method relies heavily on chemical use or novel GMO plants to develop a 'management' system for destructive crop pests.

3. *Recent conversations within the IPM community redefining IPM and lack of follow through on tactics other than pesticide applications (Zalucki et al. 2015; Peterson et al. 2018; Dara 2019). Fleet Farming's' model is an ideal system to apply multiple tactics of IPM principles with focus on arthropod-mediated ecosystem services (AMES). Again, reinforcing the need for dialog pertaining to our current, unsustainable farming practices*.

   While I was in Dr. Brewer's class "Entomology and Pest Management" this past summer, we had many discussions on the current state of IPM which were stimulated by the papers listed above. My takeaway from all this discussion is that the system that Fleet Farming utilizes to grow crops is perfect for the application of habitat management to enhance AMES in and around the 'farmlettes'. I will delve further into this as I discuss the implementation of the IPM program.

Initial framework

As mentioned previously, I started recording the presence of pests on certain crops, on which farmlettes, and the dates of these observations. This is

formatted into a spreadsheet which includes space for treatment options and extra notes. I wanted to be as thorough as possible but not overly detailed, just what is necessary for a farmer to look back and be prepared for a possible outbreak.

After keeping these records for an entire year, I began to work on pest profiles. This is a collection of common pests that I was finding on the plots, causing injury to the plants. I included basic life cycle information, host plants, a density for recommended treatment (like an economic injury level), and options for managing the pest. Most pests are identified to species but for some, like aphids, I group them together with the same basic lifecycle and management options.

The beneficial insects are listed after the pests with basic life history information. The list was compiled from my personal observations while out on the farmlettes.

All the pest and beneficial insect profiles are stored online and are incorporated into the printed IPM manual located at each branch.

After completing the profiles, I began taking inventory of any biopesticides to use for management. The labels are compiled in one file for easy access and I also made a “how to mix” guide for quick reference. The key here is

to ensure that any farmer who applies biopesticides, mixes them properly and applies the biopesticides correctly.

Considering the limited resources that I had available, I began to research control tactics for organic farms. I began with tactics to encourage and retain natural enemies (NE) through ecological based management systems. This was inspired by a bulletin released by the Sustainable Agriculture and Research Education (SARE). This bulletin included case studies on effective pest management using a whole farm approach (SARE 2003). I researched case studies on 'beetle banks', hedgerows, flower strips, trap crops, and native Florida plants to incorporate into a preventative management scheme. My goal here is to rely on the NEs until I need to treat for an issue that the NEs can no longer manage. This has been successful for some insects but is not an option for every pest.

The main concept of this IPM program is focused on rebuilding the ecosystem and relying on preventative tactics to lure and conserve NEs. When NEs fail, the fall back is usually mechanical and chemical, in our case, biopesticides. Although I have different pest complexes to focus on, the parameters are the same. Sample, monitor, and assess whether treatment is necessary. Relying on the NEs and proactive, cultural practices are the first line of defense. These tactics align best with our budget and organic principals.

Implementation

Of the plots in my branch, one 'farmlette' has a side garden full of native Florida plants. This plot, incidentally, had the least amount of pest issues during the summer of 2018. Researching the use of native plants in and around agroecosystems has returned limited results. One such study highlights the use of native plants as having advantages over non-native species (Isaacs et al. 2008). These advantages include their adaptation to the environment, a constant resource for the conservation of native beneficial arthropods, increasing floral diversity, and lessening costs associated with reseeding. My own personal observations reinforced these noted advantages. To further expound on those benefits, it has been observed that native plants thrive with proper placement in the environment and a notable increase in native arthropod diversity can be expected. This made me consider what was happening in the ecosystem of that farmlette. Each plot could then be viewed as its own unique ecosystem, each with its own history and biodynamics. All farmlettes have different soil, flora and fauna, shade/sun composition, and moisture levels. So, each plot must be viewed independently and managed as an individual system. That would be the strategy moving forward.

For my 'experimental plot' I used the Audubon Park Covenant Church's garden (Figure 2). This is where my office is located and where we store our tools. At this plot it

would be easy to monitor everything and control inputs that would be necessary for completing tasks. I would test some crop varieties here and this was where I would base most observations and sample for NE diversity.

Figure 2: Before and after photos of the church plot.

AP Church July 15, 2018 photo credit: Jeff Coco

July 14, 2019 Photo credit: Jeff Coco

I was fortunate in that I was able to build up the church plot from the flat plane that it was when I was hired. The L-shape of the plot allowed for an integration of a perennial refuge in, around, and under the bunch of papayas and fig tree. The understory is lined with perennial spinaches, such as New Zealand spinach (*Tetragonia tetragonoids),* and sweet potatoes (*Ipomoea batatas)*. The perimeter was initially filled with a couple of flowering perennials including porter weed (*Stachytarpheta jamaicensis*), African Blue basil (*Ocimum kilimandscharicum × basilicum 'Dark Opal'),* and Roma tomato plants. The tomatoes were an experiment that turned out to be very productive. I assumed that the tomatoes, placed on the perimeter, would be subject to more pest issues. However, they never had any pest issues and produced pounds of fruit.

All plots, including the church, have weed liner topped with mixed wood mulch around the perimeter. Weed liner is used between all rows on every plot except the church. At the church hay is used when available or wood mulch if necessary. The reasoning behind that is that natural mulches can potential increase the diversity of ground dwelling predators (Gonzalez-Chang et al. 2019; Minarro and Dapena 2003).

The church is designed to be as natural as possible despite being manipulated frequently due to weeding and harvesting.

Since the initial start of the flowering border around the church plot perimeter, funding has provided more perennials for many of the other plots. By the end of Fall

2019, all plots will have either perimeter flowering hedgerows or an adjacent pollinator garden. This includes many native plants as we have collaborated with a native plant nursery. Intercropping with flowering herbs such as Dill (*Anethum graveolens*) and Cilantro (*Coriandrum sativum*) is another tactic that will be employed. I personally observed that both these plants attract a high number of parasitoid wasps, hoverflies, and ladybugs.

Church plot, August 23rd, 2019

Picture above showcases a current (August 23, 2019) photo of one side of the church plot. In the forefront is African blue basil (*Ocimum kilimandscharicum* × *basilicum 'Dark Opal'*) intermixed with cowpeas (*Vigna unguiculate*) and a trap crop of mustard greens (*Brassica juncea*). Cowpeas are a multipurpose crop, essential for summertime growing here in Florida. We grow it to rebuild the soils, as it provides nitrogen, and is

has extra foliar nectaries (EFNs) for attracting NEs (Mizell 2001; Wang et al. 2006; Jamont et al. 2014). Trap crop utilizing mustard is a new tactic I am employing to help manage *Murgantia histrionica* (Hemiptera: Pentatomidae). In the southern United States this is an effective tactic to manage harlequin bugs (Ludwig and Kok 1998; Knox 1998; Badenes-Perez 2019). Harlequin bugs are a major pest on the farmlettes because of the quantity of Brassicaceae that we grow.

The aforementioned tactics are included in the preliminary management plan. As a proactive set of techniques, these fit within our budget and are manageable; results have been good thus far. I will highlight these in the section on observations.

Scouting/Monitoring

Scouting protocols began in the fall of 2018. I made modifications to the overall scouting procedure and set a day and time for routine scouting. Tuesday mornings with a start time of 8AM is the designated scouting day. A list of tools and an outline of the 'how to' of scouting and what to look for at each plot. The scouting sheet, application log, and an overview of the biopesticides is included in the supplemental materials provided in Box. The intent is to visit every plot, weekly, and assess their condition and prevent pest problems. Everything is logged for future reference.

Our Thresholds

The relative thresholds that are set for this IPM program are not traditional thresholds. We look at the abundance of pests and rank them in a simplistic density scale. In other words, low, medium, and high density. This was the easiest way for me to develop parameters in the time frame I had to complete the project. I plan on revising this in the future.

When scouting, we look for pests and we look for any NEs that are in and around the pests. These predator/prey ratios can be complex, but it is an effective method to gauge if a spray treatment or intervention is necessary. While some of our biopesticides are narrow spectrum, we still spray judiciously to not upset the balance of the ecosystem and waste product.

The densities that are used are based from observations made in the field. An estimation of the quantity that causes injury and damages.

An example: *A row of Toscano kale with 15 plants in which I would inspect about half of the plants. These Brassicas are notorious for aphids, most notably the green peach aphid Myzus persicae (Hemiptera: Aphididae). If I see aphids and no NEs, I assess based on the number of plants infested and the number per plant. If there are 1-3 plants with less than 10 aphids, I would consider this low density. 3-5 plants with aphids would be considered medium density and more than 5 plants with aphids and I would consider high and recommend some treatment. Aphids tend to infest a low number of plants until their numbers are so large that they spread. If at any point in the medium to low range of infestations there are NEs, I will allow the predator/parasitoids to manage and continue to*

monitor the population. High infestations with NEs may need some supplementary treatments to help knock back the number of pests present.

This is one of many examples that rely upon the specifics of the situations we are monitoring. With our system, I find it difficult to utilize established thresholds (if there are any) and instead monitor the system and the populations present at the time in the system.

The plan moving forward is to develop some clear-cut numbers for an individual species complex to use as a more precise guideline. For now, we have a basic rating system that can allow us to use our judgement to treat based on observations in the field. It is simple but requires some training and some knowledge about the pest and NEs which are included in the manual. The manual currently has the most common pests which includes basic lifecycle information, host preferences, and management options. The beneficial insects are listed after the pests, with most of the same criteria. I am currently working on a list of plants, both native and non-native, annual and perennial, and what insects they attract. The next step is to incorporate these specific plant species in and around the plots to increase the occurrence of beneficial insects. One such plant, sweet Alyssum (*Lobularia maritima),* is known to attract both hoverflies and parasitoid wasps (Gonzalez-Chang et al. 2019). This has become a staple on all the plots.

Three narrated PowerPoint presentations accompany the manual to provide an overview of entomology, scouting, ecosystem restoration, and knowing when to spray. For my remaining time with Fleet Farming, I will continue to educate both staff and interns on management techniques to ensure that pest management continues to perform as intended.

Spray Applications

Spray applications are administered based on the observations made while scouting. In the supplemental material folder in Box is the biopesticide sheet and an application log. It is integral to record when substances are applied to prevent over-fertilizing and over-application of pesticide. The biopesticide sheet has mixing instructions and target insects. I even included whether it is a 'bee hazard' or not. The application log allows for the recording of both pesticide and fertilizer applications. We can use this to prevent over spray and to determine whether treatments worked.

Building Healthy Soils

It was mentioned earlier that a new formulation for potting soil mix is being implemented. Our limited budget does not allow for direct amendments to the soils on the farmlettes. The concept behind this is to allow the slow release nutrients to transfer to the plots from our transplants. Building healthy soil is integral to growing healthy plants and healthy plants can deter some pests (Altieri and Nicholls 2003).

Our current soil blend contains some key components to soil health: Earthworm castings and granite dust. Both are said to aid in the microbial functions within the soil so that the plants are better able to absorb nutrients (Szimdt and Ferguson 2004; Dintcheva and Tringovska 2012; Xu and Mou 2016). The castings will help with water retention and supply some nutrients in addition to boosting microbial function.

Other components of our soil blend include *Neem cake* and *Karanja meal.* These are both dry, ground up materials from leguminous trees. The neem tree, *Azadirachta inditica,* is well known for its use as an insecticide and fungicide. Typically, it is in oil form and applied as a topical for soft-bodied insects such as aphids. The Karanja meal is from the Pongamia tree, *Pongamia pinnata,* and is currently grown in South Florida. Grown for the rich oil that is converted to biofuel, the residual seed pods get crushed and sold as feed. Interestingly, the ground seed meal and the oil (karanja) has some insecticide properties like neem (Tran et al. 2016; Roy et al. 2017; Sridhar et al. 2017). Both products supply essential macronutrients in addition to insecticidal action.

A high percentage of this soil mix is a flaked kelp meal. This provides some trace minerals including calcium and potassium which is necessary for healthy fruit production. The combination of these amendments should provide us with a healthy start to the plants while building healthy soil biota. A good start of a plants life is another proactive tool in the IPM toolbox.

In addition to these soil amendments, I was experimenting with some foliar sprays for both fertilizers and pest management. I made some mixes of limonene and karanja oil, a 1% /1% ratio, for control of aphids, mealy bugs, and flea hoppers. The was effective for aphids and mealy bugs but not very effective on the flea hoppers. I mentioned karanja's effectiveness for managing soft-bodies insects, but limonene has also proven to be effective against soft-bodied insects (Ibrahim et al., 2001; Hollingsworth, 2005).

Observations

Within the past year, I have had the privilege to work on this program and with these farmlettes. In that time, I have noticed some differences in terms of plant growth and fauna diversity. The improvements in our growing methods combined with a proactive pest management program has helped us increase crop yields. April of 2019 was the largest profit month in the history of Fleet Farming. April signals the start of the decline in our growing season, so plots were in peak production. As yield has increased, so has insect abundance and diversity. Birds frequent the plots for either the consumption of insects or seeds. The plots teem with life and I reflect on what these plots were a year prior as the agroecosystems have changed for the better.

Hymenoptera Diversity

Some of the most notable insects early in the transformation were the native Hymenoptera. The African blue basil, on a sunny day, will boast 4-5 different bees

species, Syrphid flies, and 3-4 species of wasps. It is a very welcome distraction when you are working hard and need a quick break. Florida has over 300 endemic bee species (Pascarella N.D.). Among these that I see abundantly are the Halictidae, Apidae, Adrenidae, and Megachilidae families. I have personally observed *Osmia spp.* and *Bombus spp.* visiting any tomatoes that are on the plots. Tomatoes are self-pollinating but visitation from two different species of bees could increase pollination rates and, ultimately, fruit production (Balzan et al. 2015).

Other Hymenoptera that frequent the plot includes *Polistes spp., Ammophila spp.,* Scoliidae, *Myzinum spp.,* and Braconidae wasps. I know that the Scoliids parasitize white grubs as do the *Myzinum spp.* I have personally observed Scoliids crawling out of the ground after pupation and pulling paralyzed grubs into the soil. *Polistes spp.* actively forage for both nectar and caterpillars. I have seen them remove both armyworms and melon worms.

Wasp removing a partially chewed caterpillar- photo credit: Jeff Coco

Aphid management is strong with multiple predators and parasitoids maintaining numbers at low levels. High percentage parasitism of aphids is a common occurrence

because parasitoids always have an available food source. In example, I have milkweeds growing in a flower strip at the church plot. Oleander aphids (*Aphis nerii*) feed on the milkweed, untouched, except by natural enemies. The milkweed always recovers, and the wasps have a food source which should entice them to stay on the plot.

Aphid mummies on milkweed, *Asclepias spp.*

To assist the wasps, we get large numbers of ladybird beetles (Coccinellidae), Syrphid fly larvae, and green lacewings (Chrysopidae) to manage the aphids.

Diptera Diversity

We have an abundance of Dilochopodidae around the plots and on numerous occasions have seen newly eclosed Mydas flies (*Mydas spp.*). Mydas fly larvae predate on white grubs in the soil adding a much-appreciated beneficial addition to the plots (Orfinger et al. 2018). We have a couple Hover fly species that visit the plots include *Eristalix tenax*

and *Allograpta obliqua*, with the latter an important predator of aphids and whitefly. Another interesting insect that appeared on a gaura (*Guara lindheimeri*) is the true bug *Jalysus wickhami* (Family: Berytidae). I had never seen these prior to planting that gaura at the church. According to Wheeler and Henry (1981), *J. wickhami* has a broad range of host plants, including plants in the family Onagraceous which includes *Guara spp.* Polyphagous in feeding habits, *J. wickhami* is known to feed on lepidopteran larvae, lepidopteran eggs, and aphids.

This highlights some of the visual observations I have made within the last year. Again, I chose not to sweep net sample the plots to limit any disturbance.

Ground-dwelling Diversity

Pit fall traps were set out to sample ground-dwelling arthropods. I placed twelve in total around the church plot. Placement included each corner (6) and six random in the interior. I used empty soup cans with a liner cup filled with alcohol. I baited with raw chicken at the bottom of the soup can to attract any predators. I had to do these multiple times because of unfavorable weather, and I plan on doing another round in the future.

The first set of pitfall traps revealed little in terms of diversity. There were a few wolf spiders (3) (Lycosidae), Isopods, unidentified mites, unidentified ground beetles (5) (most likely carabids), collembola, unidentified ants (6) and burrowing bugs (4) in the

Cydnidae family. Time constraints made it difficult to identify everything to Family or beyond.

Future surveys may unveil an increase in diversity but the last year, from observation, clearly shows an increase in insect activity on the plots. We have a clear understanding of our pest complex in relation to the crops we grow. Over time as the system continues to 'naturally' grow and we add more perennial habitat, this diversity should increase. Not to mention the visual appeal of these micro-farms. They are productive, full of life, and aesthetically pleasing.

Future Goals

After finalizing the project, I realized that there is much more additional material and tactics that can be added to make it more effective. Most of these tactics will be implemented after trial and error. As with any growing system, not every technique works effectively at each farm. We treat each plot independently and take each issue on a case by case basis. This is with consideration to our farming practices. Improvements will be made consistently through our growing season to better our growing system. Here I will highlight our future goals regarding the IPM program.

Develop accurate thresholds for each pest

Now that we understand what pests we must manage on the plots, we can research the individual species and develop threshold for each one. With that, certain insect groups will need a species identification, specifically aphids.

More effective cover crop system

A major bottle neck in our growing system is the availability of organic matter. Over the summer Florida can receive heavy rains which erode our rows of organic matter. One way to prevent this is to be sure the rows have plants growing to bind the soil and hold it in place. We will still get some erosion, but this should limit it and prevent complete loss. Currently, by September, we must rebuild all the plots with organic matter to ensure a healthy growing season. Finding the perfect cover crop(s) for our system is a must.

Plant-Insect list for natives and non-natives

I am working on a list of native and non-native plants and which specific insects they can attract. This will be the go-to list when setting up new farmlettes so that we can attract the proper insects for specific roles such as pollinator or predator.

This list is not exhaustive, but it is a starting point for how I want this program to grow. Farming is an art that requires constant awareness and manipulation. It is challenging and rewarding for a variety of reasons. Problem solving is a key component and that is

the challenge I enjoy the most. IPM is just one of those challenges and finding ways to stay ahead of a pest is where the real work is involved. This IPM program will continue to evolve for the time I am with Fleet Farming and hopefully after I am gone.

Conclusions

The last year and few months have been challenging as I have been both learning how to be an effective farmer and learning how to utilize my education to design an IPM program. I had not realized that I had quite a bit of knowledge on both subjects already on hand and at my fingertips. However, it was still an endeavor with the Fleet Farming System.

Multiple plots dispersed throughout a neighborhood has its challenges both logistically and with homeowners. Over time it has been easier to manage despite some issues that we still need to work out. Overall, I am convinced that the system works. Diversity alone has shown me that our efforts are not wasted.

Our plan stays the same with adaptations to the variety of situations we may encounter. We are feeding our soil, which is arguably, the most important component of growing plants. The soil additives that we are using will cultivate the necessary microbes that aid plant health. The same microbes should aid in some management of nematodes when present. In our case, we deal with root-knot on a variety of crops. We rely on routine crop rotations and building the soil community with organic matter.

Soil health, routine cultural practices, and rebuilding the habitat is the main formula for managing our plots. We view this as a blueprint for sound, ecological management of our agroecosystems. Disturbance is minimized as is the usage of outside inputs such as fertilizers and pesticides. This is how we protect the environment while we farm. It is my hope that urban farming continues to grow and with it these sustainable farming practices for current and future farmers alike.

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