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UV Fluorescent Powders as a Tool for Plant Epidemiological Studies

Paul M. Severns [1,2,*], Clarence Codod [1,3] and Ashley J. Lynch [1,4]

[1] Department of Plant Pathology, University of Georgia, Athens, GA 30602, USA; cbcodod@ucdavis.edu (C.C.); al27635@georgiasouthern.edu (A.J.L.)
[2] Center for the Ecology of Infectious Diseases, University of Georgia, Athens, GA 30602, USA
[3] University of California-Davis, Salinas, CA 95616, USA
[4] Department of Biology, Georgia Southern University, Statesboro, GA 30458, USA
* Correspondence: Paul.Severns@uga.edu

Abstract: Some basic aspects of plant disease epidemiology remain largely unknown due to a lack of empirical study methods to experimentally manipulate the position of infections within a single plant or within a plant canopy and the dispersal behaviors of small insects that vector important plant diseases, for example. We present two methods using UV fluorescent particles that, when mixed in a 10% ethanol solution, can be used to create surrogate fungal infections on plant leaves and to field mark whiteflies in situ. When we used a custom-made experimental chamber to measure the velocity of falling particles, we found that the UV fluorescent particles had settlement velocities that overlapped with known fungal plant pathogen spores. In a separate experiment, field applied marks to whiteflies, *Bemisia tabaci*, were used to estimate straight-line insect vector displacement from source plants as a simple dispersal gradient over a limited distance in a 48 h period. The UV fluorescent particles and airbrushes were relatively inexpensive (USD < 100 total), easily sourced, and usable in a field setting. We believe that the approaches and methods shared in this manuscript can be used to design specific experiments that will fill important plant epidemiological knowledge gaps in future studies.

Keywords: fungal plant pathogens; whiteflies; *Bemesia*; fungal spores; small insect marking; plant disease spread

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1. Introduction

Plant diseases play important roles directly shaping human culture [1–3] and impacting how humans interact with both natural [4,5] and agricultural ecosystems [3,6,7]. Although some aspects of plant diseases are intensively studied and understood because of their direct impact on food production (e.g., host interactions, host resistance/susceptibility, pathogen life cycle), plant disease dispersal is particularly challenging to experimentally study, and research methods limit a basic understanding of plant epidemics. For example, many viral and bacterial plant diseases are vectored and spread across the landscape by relatively small invertebrates (<5 mm) through feeding, movement, and settlement patterns [8]. Invertebrates such as whiteflies, thrips, mites, aphids, and sharpshooters all have feeding, settlement, and active and passive (wind-aided) dispersal behaviors, which influence the patterns of plant disease spread. Logically, it follows that understanding the determinants of vector settlement, feeding, and movement motivation (e.g., local exploration versus dispersal) is important for understanding plant disease spread. Yet, the methods to study invertebrate behaviors are typically limited to passive traps (sticky card traps, pheromone traps, and pitfall and pan traps), active sampling (sweep netting and rotorod impact sampling), and field counts of mostly, if not exclusively, anonymous individuals [9–11]. Excluding instances where vectors are intentionally released and there are no naturally occurring vectors present, invertebrate-vectored plant disease studies are restricted to descriptions of the abundance and density (vectors and disease) of anonymous

individuals as they change over space and time. In this type of observational study, the assumptions are that density shifts over space and time are made by the individuals being monitored as opposed to different individuals emigrating and immigrating out of and into the research area.

Similar limitations and exceptions also apply to the study of wind-dispersed fungal plant diseases. Compared with invertebrate-vectored plant diseases, fungal plant disease outbreaks are more readily initiated and experimentally confined to a predefined area, at least in the initial outbreak generation. In these instances, disease spread from a precisely delimited outbreak area can be represented (in part) by a dispersal gradient, a statistical expression of a decreasing distribution, such as a probability density function, that generally describes how much disease is likely to occur at various points in space [12–14]. However, plant fungal disease dispersal studies are functionally challenged by the co-occurrence of spores of similar morphology produced by different pathogens and naturally occurring infections of the focal pathogen that are unaccounted for in the experimental area [15]. Due to such limitations, there remain basic questions about the patterns of plant disease spread that are difficult, if not impossible, to empirically study.

UV fluorescent powders have a relatively long history of use in ecological studies, most notably in tracking the paths and dispersal of small mammals [16–18] and reptiles [19,20] and displacements of larger insects [21–23]. But the use of these powders with insects typically requires a capture–mark–release approach, which can limit and potentially impact the dispersal behavior of the marked insect [21,22,24]. Historically, UV powders were limited to just a few colors (orange, blue, green, and yellow), but now, UV fluorescent powders can be found in a range of particle sizes and with a wider range of colors. Despite their relatively long history of use in field studies, UV fluorescent powders are rarely used for the epidemiological study of insect-vectored plant diseases. However, the use of these powders may enable researchers to pose and answer questions that current approaches do not readily allow.

In this manuscript we describe two different applications of UV fluorescent powders that may facilitate the study of plant disease dispersal. First, we present the use of UV fluorescent particles as a potential surrogate for fungal plant pathogen spores, quantifying their settlement velocity and comparing these velocities to fungal plant pathogen spores reported in the literature. Second, we present a method for the in situ field application of the UV fluorescent particles that adhere to the wings and bodies of whiteflies (*Bemisia tabaci*), an important vector of viral plant diseases.

2. Materials and Methods

2.1. UV Fluorescent Particles

We sourced the particles (strontium aluminate glow in dark powder) for this study from the company TechnoGlow™ (www.technoglowproducts.com, accessed on 14 October 2024), which offered variously colored particles in sizes 5 to 50 µm (Figure 1). The MSDS sheet section 4.2 states that "the product is not harmful to human health effect", but the powders are labeled as "toxic to aquatic life with long lasting effects" in section 2.2 Hazard Statement H411. It is not clear what concentration threshold was toxic to aquatic life, which aquatic organisms were evaluated, and what were the long-lasting effects on aquatic life. We presume that in the limited quantities used in our studies (<1 g) that the potential impacts on aquatic life would be unlikely to be realized in a large arable, agricultural landscape.

2.2. Application of UV Fluorescent Particles as an Ethanol/Water Mixture

We first experimented with a 100% aqueous solution (0.5 g powder/4 mL of water) and found that the particles were too hydrophobic to readily mix into a slurry for application. When the 100% water solution was mixed at ~45 °C in a vortex machine, the particles formed a homogenous mixture, but they did not adhere to any surface sufficiently well and were easily dislodged after drying as large flakes, rather than spore-sized particles. After a dilution series experiment with ethanol and water, we found that a 10% ethanol solution

generated the desired application properties and released individual particles applied to paper and glass with a 1 km/h air current (2 s) and gentle physical touch (much like the spore-producing area of a plant fungal pathogen infection). This 10% ethanol solution was applied to glass, paper, and plant leaves, and all shed individual particles with a pulse of low-velocity air and gentle physical touch. However, the 10% ethanol mixture on glass was more easily dislodged with a can of compressed air and could be removed as flakes with one's fingernail. For the 10% ethanol mixture, the applications made on paper were more resilient to flaking and were mostly dispersed as particles and small clusters of particles. When the 10% ethanol mixture was applied to leaf surfaces, the air-dried applications did not dislodge in flakes and were mostly dispersed as individual particles (5–15 min, depending on humidity and temperature) (n = 15 trials on each surface type).



Figure 1. (**Left**): custom-constructed apparatus to estimate settlement velocity of small particles in ambient air (tube length = 99 cm × 5.7 cm diameter pipe, chamber = 25.5 cm × 30.5 cm × 30.5 cm). (**Upper right**): example of some TechnoGlow™~5–50 μm UV fluorescent particle colors. (**Bottom right**): inside view of the apparatus chamber lined with long-wave UV LED light strip tape turned on.

Increasing the percentage of ethanol caused the mixed powders to become more viscus and sticky. A single hard pellet was formed at 80% ethanol and above, with the pigment leaching out into the solution. We did not evaluate any ethanol solution <10%, so it is possible that the degree of stickiness may be customized through slight increases or decreases in ethanol concentration. We also attempted to create a solution with 99.8% water and 0.2% Tween (a surfactant). This approach was completely ineffective at producing a semi-aqueous solution as the surfactant appeared to render the fluorescent particles unmixable. We applied the 10% ethanol mixture with several tools including a microbrush, cotton swab, paintbrush, and a USB rechargeable, cordless airbrush. These tools are often used for the fine-scale application of makeup, are widely available, and can be USD < 70 for a cordless airbrush.

2.3. UV Fluorescent Particles as a Surrogate for Plant Pathogen Fungal Spores

An initial pilot study revealed that we could apply the 10% ethanol UV fluorescent particle mixture to the surface and underside of leaves on potted plants and that the particles released from these surrogate fungal plant infections could be trapped on downwind plants. Briefly, we performed three replicates of a confined space experiment (20 °C–22 °C, ~50% relative humidity) to determine whether a gentle wind could dislodge and disperse particles from a source plant to recipient spore traps nestled within a series of live potted daylily (*Hemerocallis* sp., Asphodelaceae) plants. In these experiments, 20 s of a 2 km/h and 4 km/h wind generated by a fan placed behind the source plant containing one hundred 5 mm radius, surrogate infections per plant. Particles were readily dislodged and deposited on petroleum-coated artificial leaves made from an overhead transparent plastic film nestled with the canopy of plants positioned downwind at 1 m, 2 m, and 4 m. A crude count of the particles deposited on the artificial leaves (viewed under 60× magnification) revealed hundreds of particles on all recipient plant leaves at 1 m, 2 m, and 4 m downwind locations at both wind speeds. These results suggested that the UV fluorescent particles in a 10% ethanol solution could possibly serve as a surrogate for a fungal plant disease-producing spores.

To more formally evaluate whether the fluorescent UV particles could serve as a surrogate for fungal plant spores, we evaluated whether the particles may have a similar settling velocity to known fungal plant pathogen spores. Particles in air can be characterized, in part, by their density and dimensions and the velocity at which they fall (settling velocity) and included in projections based on Stokes Law. The fluorescent UV particles ranged in size from 5 μm to ~50 μm, which is similar to the range of single spore and aggregate fungal plant pathogen spore sizes [25]. We used a custom-built chamber connected to a 5.7 cm diameter metal pipe with a length of 99 cm, the top of which was open so that particles could be released and velocities measured as they passed through the chamber (Figure 1). The chamber (airtight lid and sides) had a gasket (~airtight when sealed) in which we secured a digital camera. The interior of the chamber was lined with long-wave UV LED light strip tape to illuminate the closed chamber (Figure 1). We chose to use UV LED strip lights because of their low heat output and because the particles can be clearly observed as they fall through the illuminated chamber. Although the particles were brightly colored and viewable under visible light, long-wave UV makes the particles even more conspicuous and easier to track. In the past, spore velocity settling experiments have been conducted using flash photography, which can generate heat in the chamber, causing a microburst updraft capable of impacting particle velocity. However, we used a digital camera that was capable of capturing images in low light and recorded videos at 60 frames per second without the use of a camera flash. This method enabled us to inspect the image frame by frame and approximate the distance traveled by the particle against a metric ruler (mm) positioned within the target area for particle deposition (Supplementary Video S1).

In a stable room environment (~21 °C, ~45% relative humidity), we released spores gradually from the top of the chamber opened for ~20 s while the digital camera recorded a continuous movie from 5 s before to 10 s after the release of the UV fluorescent powder. We used pink particles because they were the most conspicuous when we viewed the movies, and it was easier to track their distance traveled over time than when we experimented with a darker color (e.g., blue). We evaluated the movie, frame by frame, and tracked individual particles as they fell, recording the time and distance traveled. To determine whether the UV fluorescent particles may be a potentially suitable surrogate for fungal plant disease spores, we compared the UV fluorescent settlement velocities to fungal plant pathogen spore settlement velocities reported in the literature.

2.4. Marking and Whitefly Tracking

Initially, we collected whiteflies, *Bemisia tabaci*, from an infested experimental agricultural field in Tifton, GA [11], which we used to perform marking experiments in controlled conditions before attempting the field marking and recapture of dispersed individuals. *Bemisia tabaci* are problem pests on agricultural crops throughout the world, causing plant

death from herbivory but also the plant pathogens (particularly viruses) they vector (acquire and transmit) while feeding [26]. Because adult whiteflies are relatively small, ~2 mm in total length, studies of their dispersal rely on passive sampling and the change in relative abundance over time [11]. The assumption is that the same whiteflies move from one region (which is dense) to another region (which is less dense) with a shifting mosaic of whitefly densities across a broader landscape within a short time period (several days to a week). For whitefly-vectored plant diseases, however, the latent period tends to be relatively long compared to the whitefly adult lifespan, and plant disease can intensify long after whiteflies have abandoned those plants, generating asynchrony between whitefly abundance, dispersal and the onset of disease [11,26]. A method for field marking whiteflies would enable researchers to generate direct observations of displacements from a known origin and perhaps better understand disease and vector dynamics.

We developed a method of marking whiteflies featuring UV florescent particles in a 10% ethanol solution using cordless, USB rechargeable airbrushes, after discovering that dry particle application with an airbrush did not result in a useful level of multi-day adhesion to the surface of live insects. Initially, we trialed three different types of cordless airbrushes (USD 50–80), but we settled on USB rechargeable airbrushes with variably controlled air pressure (as opposed to a fixed air pressure) and models in which we could control the airbrush aperture shape. These two features provided a more refined control of the particle mixture application and more flexibility when applying field marks.

We conducted a pilot study to evaluate the potential for short-term mortality on insects after being marked with the 10% ethanol fluorescent UV particle mixture. We collected aphids (n = 40), hemipterans (n = 10), and cicadellids (n = 8) infesting ornamental but unmanaged plants and split them evenly into two groups (control and sprayed) and then housed them in containers with adequate access to water and food resources to observe any differences in mortality within 4 days of applying the mixture with an airbrush. None of the individuals died within the 4-day observation in either group, so we proceeded with focused testing on whiteflies. We collected whiteflies (~100) from an experimental field infested with whiteflies [11] and separated the adults evenly into two ~0.5 m × 0.5 m × 0.5 m mesh plastic cages (BugDorm, https://shop.bugdorm.com/, accessed on 14 October 2024) to closely monitor the short-term impacts of spray applications. We applied the same mixture (0.25 g UV pink particles/1 mL of 10% ethanol) to the underside of broccoli leaves containing the adult whiteflies with the airbrush, lightly coating the underside of the leaves and the whiteflies, in a room temperature of ~22 °C. We also sprayed the control whiteflies with water using a different airbrush (to avoid cross contamination). After the particle solution dried, ~5 min, we checked the whiteflies in both cages 2 h later to record any evidence of mortality and then at ~12 h, ~24 h, and ~36 h. We did not detect any mortality in either the UV particle-sprayed or water-only cages, so we suspended a yellow sticky card from the top of the cage and moved the cages into the sun. This enabled us to evaluate whether the water-sprayed and marked whiteflies would fly from the application area and be captured with a commonly used insect sampling method. Sticky cards in both cages captured at least 15 whiteflies, so we proceeded to conduct a proof-of-concept field study.

2.5. Field Experiments on Naturally Infested Whitefly Squash Plants

In the last week of September and first week of October in 2022, we selected multiple-source squash plants in an experimental set of plantings at the University of Georgia—Tifton Campus Experiment Station to field mark and capture dispersing whiteflies on 15 cm × 8 cm yellow sticky card traps. Between 9:00 a.m. and 12:00 p.m., on two separate days one week apart (22 °C–26 °C, 65–80% relative humidity), we arbitrarily selected 2 and 3 whitefly-infested source plants within a row of squash plants and used a cordless, USB rechargeable airbrush loaded with a mixture of 0.8 g of pink, fluorescent UV particles in 1.5 mL of 10% ethanol to coat the underside of two leaves containing from ~100 to 450 adult whiteflies in total (Figure 2). Source plants were separated by 4 planting rows, ~7 m, and were separated by at least 10 m up or down the planting rows from each other to reduce

potential cross contamination between the source plants. The UV particle mixture was applied as uniformly as possible to the underside of the infested leaves (Figure 2). Once the application was finished for each leaf (<1 min per leaf), the leaves were returned to their natural resting position. We did not observe the whiteflies dispersing from the plants during the marking process or within the 15 min following application. This was possibly due to the application occurring in the morning when the temperatures were relatively cool with unfavorable whitefly flight conditions. We positioned four yellow sticky card traps (10 cm × 18 cm) at 0 m, 1 m, 2 m, 3 m, and 4 m distances from the source plants along two directions up and down rows. Sticky cards were positioned from metal stands positioned ~0.46 m inches off the ground but above the outer margins of the squash leaf canopy. The sticky card at 0 m was placed over the top of the two leaves where the whiteflies were marked. We left the sticky cards in the field for 2 days, after which we counted the number of marked whiteflies with a dissecting scope and a hand-held UV LED flashlight as a light source (Figure 3). Any whitefly with a detectable UV particle was counted as a marked individual. We plotted the marked whitefly counts versus the distance from the source plants and overlaid the individual dispersal gradients, both up rows and down rows, onto the same figure. If the field marking technique is reasonably successful and potentially useful, we should observe the marked whiteflies to form a dispersal gradient from the source plants (e.g., decreasing marked whitefly counts with increasing distance from the source).



Figure 2. (**Left**): underside of a rolled leaf in the process of UV particle mixture application showing pink areas and whiteflies (*Bemisia tabaci*), small linear white objects. (**Right**): Confirmation of dispersal of marked whiteflies (2 with a fluorescent pink particle attached) to a neighboring untreated leaf, with unmarked whiteflies also present. This image was taken with a standard phone camera with a hand-held UV LED long-wave flashlight, indicating that digital camera phones are sensitive enough to be used to gather data from image capture.

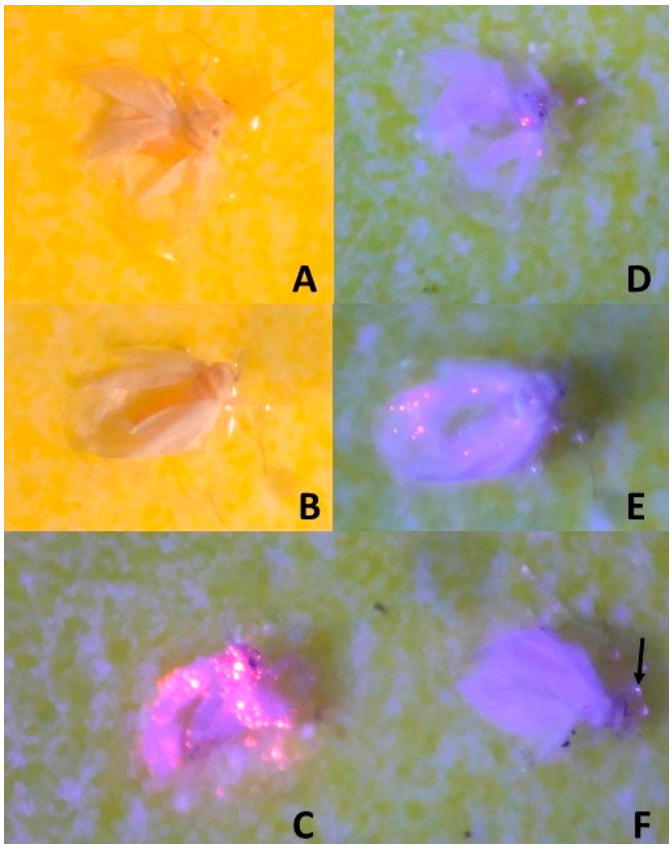


Figure 3. Images of whiteflies (*Bemisia tabaci*) with UV particles attached on the yellow sticky cards. Image pairs (**A**/**D**) and (**B**/**E**) are the same individuals under normal light (**A**,**B**) and long-wave UV LED-generated light (**D**,**E**). Images (**C**,**F**) represent the extremes of particle adhesion with many attached particles (**C**) or one particle attached to an antenna (black arrow (**F**)).

3. Results

3.1. UV Fluorescent Particle Settlement Velocity

From multiple movies of falling particles, we were able to unambiguously track and estimate the settlement velocity of 53 pink UV fluorescent particles (Table 1). The mean velocities of the dry particles overlapped with the values reported in the literature for plant pathogen spores and plant pathogen spore surrogates (Table 1). Our observed range of UV particle settlement velocities was greater than in some reported fungal pathogen studies, except for the study reporting the mean settlement velocity of *Uromyces phaseoli*, which was similar to our highest UV particle settlement velocity (Table 1).

Table 1. Mean and range of observed settlement velocity values for the UV fluorescent particles in the present study and similar-sized spores and spore surrogates from the published literature.

Particle Type	Mean Settlement Velocity	Observed Range of Settlement Velocities	Source
TechnoGlow UV fluorescent particles (n = 53 observations) (~5 to 50 µm)	0.0343 m s^{-1}	0.019–0.075 m s^{-1}	Present study
Polyurythane spheres *Plasmopara viticola* surrogate (10 to 45 µm) single spores and spore clusters	0.035 m s^{-1}	0.028–0.039 m s^{-1}	[27]

Table 1. *Cont.*

Particle Type	Mean Settlement Velocity	Observed Range of Settlement Velocities	Source
Uromyces vicia-fabae (~10 to 50 µm) single spores and spore clusters	Not reported	0.008–0.016 m s^{-1}	[28]
Uromyces phaseoli ~20 µm (mean single spore)	Single spore 0.086 m s^{-1} Spore cluster 0.113 m s^{-1}	Not reported	[29]
Phakopsora pachyrhizi (10 to 15 µm) single spores	0.0187 m s^{-1}	0.011–0.035 m s^{-1}	[30]

3.2. Marked Whitefly Dispersal in the Field

We field marked the whiteflies either resting or feeding on the underside of two infested squash leaves from five different source plants. After two days, a proportion of the marked individuals were trapped on sticky card traps up to 4 m, demonstrating the dispersal of marked individuals (Figure 4). The number of captured individuals was occasionally high when the sticky card was positioned over the source leaves (0 m), >100 marked individuals in some instances, and we observed a decrease in trap efficiency with increasing distance from the source plants (Figure 4). These sticky card counts of marked whiteflies generated a dispersal gradient, which appeared consistently between the replicate source plants (Figure 4).

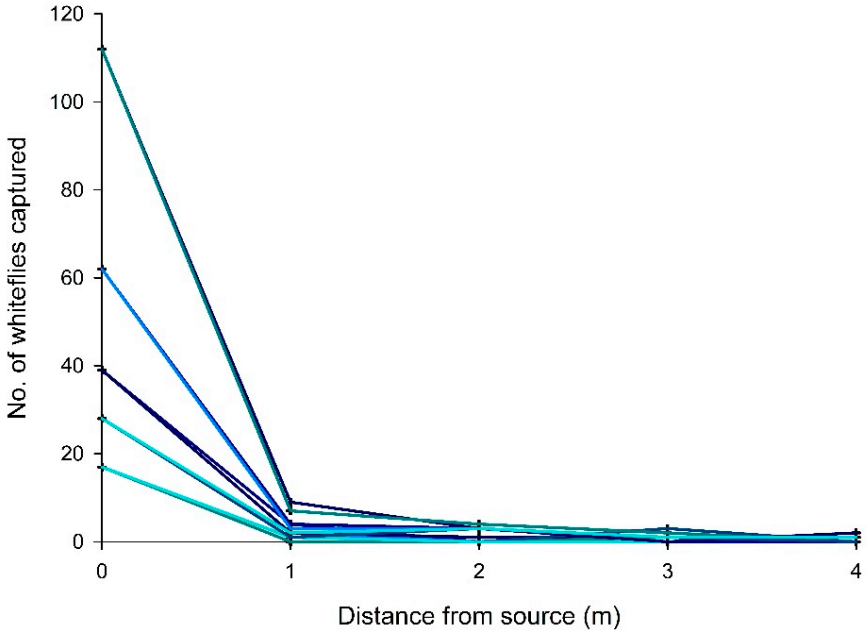


Figure 4. Marked whitefly (*Bemisia tabaci*) counts with distance from the five source plants on yellow sticky card traps at the end of 2 days, following the initial field marking events. Similar colored blue lines represent the up row and down row counts from the five source plants on yellow sticky card traps at 0, 1 m, 2 m, 3 m, and 4 m.

4. Discussion

We present evidence that a 10% ethanol mixture of UV fluorescent particles ranging in size from 5 µm to 50 µm may be used to as a surrogate for sporulating fungal plant disease infections and as a means for marking and tracking small arthropods that vector plant diseases. These UV fluorescent particles are relatively easily sourced (they are used in the festival of Holi—the Hindu celebration of colors, love, and the spring) and are broadly approved for human use. Moreover, the application tools we used were

relatively economical, with the most expensive one being a cordless, USB rechargeable airbrush (USD < 80) and the UV light was generated by inexpensive, hand-held, LED lights. However, the use of these UV fluorescent particles comes with some limitations.

As a surrogate for fungal plant disease spores, the settlement velocity of the UV particle mixture does overlap with the values reported in the literature for known fungal pathogen spores of similar lengths. However, settlement velocity is only one aspect of particle dynamics that should be considered before some experimental uses as the particles are not sufficiently characterized for a refined particle flow experiment. First, the shape of the UV fluorescent particles is relatively flat when compared with many plant pathogen spores, which tend to be spherical or cylindrical [25]. Spore dimensions and shapes can cause the particle to respond to turbulence in different ways, so these UV fluorescent particles are unlikely to function precisely as a fungal pathogen spore, meaning they may not be useful in a precise particle flow model that invokes Stokes Law [31]. Furthermore, we do not know the UV particle density or its friction coefficient attributes, so these UV fluorescent particles are unlikely suitable for detailed escape velocity studies. The scenarios in which these UV fluorescent particles may function the best are upon evaluating the basic patterns of spore dispersal and deposition, such as comparing the dispersal and deposition of spores produced on different parts of a plant or different regions within a plant canopy to each other. The contributions of infection and spore production location to the patterns of disease spread have been elusive and difficult to empirically study, but these are important aspects of plant epidemiology still remain largely speculative. How we used these UV fluorescent particles may have an important advantage over other surrogates, such as polyurythane spheres [27], in that we can apply the particles directly to a leaf or stem, accounting for infection and spore-producing area dimensions through the precise placement of the mixture and the adjustment of particle density to represent different spore production scenarios. Informal experimentation on leaves with UV particle applications in field conditions experiencing heavy rains, direct sunlight, heat, wind, and other exposure-related conditions persisted for at least 2 weeks when they occurred on the upper side of leaves and up to two months when the applications occurred on the sheltered, underside of leaves. In this respect, the artificial infections did appear to persist in a manner similar to the infectious period of fungal plant pathogen infections, but the surrogate infections also disappeared with time. To our knowledge, no other surrogate fungal spore material displays these potentially useful properties.

As a method for marking and tracking small arthropods, the use of fluorescent powders is not new and has been used to different degrees of success [21–24]. The method and approach we present differs from typical methodologies in that we can directly apply the marks in a field setting and reduce the potential impacts on vector behavior. Traditionally, the use of fluorescent powders to track arthropods involves first collecting or raising the vectors and placing the captured individuals into a container where the powder is added and subsequently shaken to facilitate coating the vectors' bodies, wings, antennae, head, and legs with powder. The marked individuals are then transported to a preselected release location (or locations) and then allowed to disperse [21–24]. There are some potential disadvantages to these traditional methods. First, the powder is applied dry, and while it may stick to the vectors initially, the particles can be lost with time (one can imagine this occurs more rapidly for more active and vagile vectors). Mixing the UV fluorescent particles in a 10% ethanol solution caused the particles to become sticky, and once dried (5–15 min), they appeared to adhere to the whiteflies compared to the traditional dry powder application method (personal observation). However, because we did not rigorously test survival over longer periods of time, there may be some impact of the ethanol or the combination of ethanol, water, and the UV particles that may reduce the longer-term survival rates of marked individuals.

Capture and confinement, then immersion in a fine particulate and considerable agitation due to mixing, followed by release (potentially in a new area that the individuals have never experienced) could induce abnormal vector movement responses upon release.

This could be an issue if one is tracking initial movements and conceptualizing those as typical (either as a persistently sedentary or as a vagile disperser) [32]. While the application of the particles with an airbrush is also admittedly unnatural, the advantage of in situ marking may be still preferable to traditional capture–mark–release methods. With our field application method, the disturbance time period was typically <1 min. The individuals were not removed from the location in which they naturally settled, and it is possible that once the marked individuals dispersed, they did so in a more natural manner. With the availability of multiple UV fluorescent particle colors, one can imagine a spatially explicit study design where groups of vectors within a well-described origin area can be marked and compared with other groups of individuals occurring in origins with conditions that differ in quantified descriptors. Much like the study of the location of fungal plant spores, the dispersal ecology of plant insect vectors is only superficially understood, yet vector dispersal behavior and feeding is most certainly important for understanding the patterns of invertebrate-vectored plant disease spread.

5. Conclusions

Using readily sourced UV fluorescent powders with particle sizes ranging from 5 μm to ~50 μm, we were able to create surrogate fungal plant disease infections that were capable of shedding UV fluorescent particles which overlapped in length and terminal velocity with spores of known plant pathogens. Surrogate infections could be placed on any vegetative surface and facilitate spore dispersal studies where precise locations of infections on a single plant, between plants, or positions within a plant canopy can be compared without the introduction of a plant disease or multiple plant diseases. Using the same particles in a 10% ethanol solution, we field marked whiteflies at specific locations and recorded their short-term and near-source patterns of dispersal using yellow sticky card traps, which generated a vector dispersal gradient. The use of UV fluorescent powders of different colors should enable the empirical study of important and basic aspects of plant disease epidemiology that are poorly understood without the risks associated with experimentally initiating a plant disease outbreak and through more precise tracking of small, difficult to mark, insect vectors from in situ marks.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/agronomy14102405/s1, Video S1: UV particle movie.

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Data Availability Statement: UV particle settlement velocity data are available upon request.

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