Introduction and Literature Review

Extension programs, and thus Extension specialists and educators, are the public face of plant pathology (Horne, 1981). Extension plant pathologists undergo advanced training in plant pathology and are responsible for translating research results into teachable and practical information (Agrios, 2005; Everts et al., 2012; Hardwick, 2002; Jacobsen, 1983). Extension plant pathology programs worldwide are understaffed (Horne, 1981), and so pathologists must carefully consider the worthwhileness of all decisions before investing program resources. This is especially true for communication resources to effectively share knowledge on managing plant diseases, increase profitability for growers, and improve sustainability of agriculture and horticulture industries (Diem et al., 2011; Everts et al., 2012).

The ability to engage different audiences is a vital element of efficient and effective Extension programming (Plastina et al., 2019). For Extension plant pathologists, today's clientele differs greatly from when cooperative Extension services were established with the passing of the Smith-Lever Act of 1914 (Jacobsen et al., 2008). Extension programs are attempting to serve a constantly broadening clientele base (Knutson, 1986). No longer limited to farmers and the rural community, Extension programs must also reach nonprofit organizations, private industry, consultants, hobbyists, master gardeners, and the general public (A. Klodd, personal communication, October 7, 2019; Everts et al., 2012; Jacobsen et al., 2008). The demographics of agricultural Extension audiences are also constantly changing, and the 2030 audience is predicted to be younger, more educated, and more diverse (Plastina et al., 2019).

Unfortunately, constraints on resources—such as reduced local, state, and federal funding—have complicated traditional methods used to reach Extension audiences (Everts et al., 2012; Hendrickson et al., 2010). Limitations with current methods of communication include: (a) inability to expand programs to new audiences while continuing to meet current needs because of decreased budgets and personnel (Everts et al., 2012; Hendrickson et al., 2010); (b) direct contact between Extension specialists and clients requires availability of both parties at the same time and place, which can result in gaps of knowledge for audiences with scheduling conflicts (Xie & Gu, 2007); (c) large amounts of time, resources, and funds may be required for Extension specialists and clientele to attend meetings or events (Xie & Gu, 2007); and (d) inclement weather conditions can constrain travel for Extension specialists and clientele and cause cancellation of outreach events (Xie & Gu, 2007). The inability to adapt may lead to delays in responses to plant disease issues, reduced crop yields, and increased economic losses.

To accommodate this new environment, Extension programs have become more strategic and entrepreneurial (Fisher, 2009). Platforms of Extension program delivery are constantly changing; however, traditionally Extension experts have relied on face-to-face meetings, field days, and using online and printed materials (Arbuckle, 2017; Plastina et al., 2019). Although these have been dominant approaches for programs, it does not mean plant pathology Extension clientele or Extension plant pathologists prefer these methods, and they may not be the most efficient and effective forms of communication. The demand for online resources has been increasing, as is the demand for increased technology to improve work efficiencies and expand audience outreach (Diem et al., 2011). This makes sense, as online programming can help increase exposure, improve flexibility of content, and facilitate access to materials and information, while reducing monetary costs (Rich et al., 2011). Webinars have worked well for outreach efforts as they allow hosts to tailor information and connect new audiences to educational materials (Allred & Smallidge, 2010).

Other forms of digital communication that have not been as widely utilized—like podcasts—should not be overlooked (Arbuckle, 2017). Podcasts offer significant potential for use in plant pathology Extension programs. Growers have previously indicated a preference for radio as a mass media communication platform (Licht & Martin, 2007). However, farm radio's decline has left some rural communities without agriculture news (Fannin, 2006). Podcasts have the ability to effectively fill this void, as well as supplement other online formats like webinars (Fannin, 2006; Rhoades & Aue, 2010).

Podcasts are growing in popularity and are suitable for delivering different types of information. The Infinite Dial (2018) found the number of people listening to podcasts has steadily grown over the past 12 years in America, and an estimated 124 million people ages 12 and older, 44% of the studied population, have listened to a podcast (Edison Research & Triton Digital, 2018). A wide variety of other fields have incorporated podcasts into their communication and education programs to reach large and diverse audiences, accommodate the needs of current audiences, and overcome limitations in established communication and education platforms, including medical schools, journalism and broadcast productions, libraries, and universities (Lien et al., 2018; Porter, 2006; Sellers, 2007; Wolpaw & Toy, 2017). According to Kelly (2017), the preferred podcast genres by podcast fans have been comedy (48%), education (40%), news (38%), sports (27%), politics (22%), gaming (18%), and technology (16%). Between 2004 and 2010, the total number of science podcast shows grew linearly and from 2010 and 2018 the total number of science podcast shows grew exponentially (MacKenzie, 2019). Tohill (2008) reports that experts have used podcasts to teach engineering and science (33.3%), computer and information technology (33.3%), and business and law content (13.3%).

Podcasts are inexpensive to create, easy to distribute, portable, and can create better learner engagement compared to traditional lectures and textbooks (Back et al., 2017; Lien et al., 2018). The ease of accessing podcasts and ability to listen to a podcast at any time, in any location, in conjunction with the ability to simply produce and distribute podcasts has led to the popularity of podcasts for the consumer and creator (Lien et al., 2018; Ormond, 2008). Due to the portability of podcasts, time-constrained listeners can learn educational content without adding additional time demands to their busy days (Shekarchi et al., 2018; Wolpaw & Toy, 2017). The ability to listen to a podcast when most convenient for a user and to stop, adjust the speed, replay, and review a podcast before proceeding to the next section can also help facilitate better management of information (Schreiber et al., 2010). Podcasts can be adjusted to facilitate self-paced learning and meet the needs of slower learners, advanced learners, non-native speakers of the presentation language, and those with learning disabilities (Walls et al., 2010). Knowledge can also become accessible to those who otherwise may not be able to attend and enroll in traditional training (Malan, 2007). When comparing podcasts to live lectures, a study found student podcast users' knowledge acquisition and retention to surpass the effect of live lectures (Raupach et al., 2015).

This convenience is important to Extension audiences. Many Extension clients are unable to devote time or financial resources to traveling and attending meetings and seminars during the growing season because they spend a significant amount of time on their farms or working in jobs off their farms. They need to obtain information through quick and convenient methods (Norman, 2010). Traditional Extension audiences have indicated a preference for a combination of self-delivery communication methods, such as audiocassettes, and traditional delivery methods, such as in-person meetings (Cladwell & Richardson, 1995; Okwu & Daudu, 2011).

Some agricultural Extension programs have started successfully leveraging podcasts to communicate with clientele. An analysis of website traffic to the Industry and Investment New South Wales (NSW) website found 13 dairy podcasts generated 3.65 times the downloads of the top 13 PDF publications during a 13-month period (Mills, 2011). In 2006, after including podcasts as part of their online communication, the Arkansas Extension program found their news website increased by 2,000% in visits over the course of the year (Norman, 2010). A survey of audiences of the Extension *Soybean Podcast Alerts* podcast at the University of Arkansas at Little Rock found the following as notable podcast features: the ability to select for topics of interest, convenience, portability, and ease of use, and audience members expressed interest in receiving podcasts that addressed other topics related to agriculture (Norman, 2010). Other researchers have found value in using podcasts to reach a wide variety of Extension audiences, including tilapia farmers in the Philippines (Bolivar et al., 2012), youth across social identity groups (Gonzalez et al., 2019), and families (Smith & Davis, 2008).

A study of the effectiveness of dairy podcasts created by Industry and Investment NSW found podcasts as a useful tool for future Extension programs because of their level of acceptance by their clients and the low start-up and ongoing costs associated with production and distribution of podcasts (Mills, 2011).The success of podcasts developed by agricultural Extension programs such as the Industry and Investment NSW, Arkansas Extension program, and Texas A&M University supports investigation into the use of podcasts for plant pathology communication. When Texas A&M University integrated RSS podcast technology into their programming, they became the first land-grant institution in the United States to make RSS podcast technology available (Fannin, 2006). The podcast, *Agnews Weekly*, at Texas A&M began with no budget. The podcast intended to reach agricultural producers, but its audience expanded to general news consumers and the mass media (Fannin, 2006). Another podcast, *What's Killing My Kale?*, produced by the University of Minnesota for fruit and vegetable farmers in the Upper Midwest, found its podcast also reached an unintended audience of hobbyists (A. Klodd, personal communication, October 7, 2019).

Despite the popularity of podcasts, published scholarly research on podcasts is limited and most studies conducted during the platform's infancy (Bottomley, 2015). Further, to date, there are no studies regarding plant pathology Extension programs and their use of podcasts. The purpose of this study is to examine how podcasts can be leveraged to share key plant pathology information and to explore their potential usefulness for reaching the varied audiences of Extension professionals. Using content analysis methodology, researchers developed a characterization of the available information in podcasts related to plant pathology and shared recommendations about how to incorporate podcasts into Extension plant pathology programs.

Theoretical Framework

Plant pathology Extension clientele are a diverse group of learners, including farmers, consultants, agribusiness, nursery workers, homeowners, and numerous others (Jacobsen et al., 2008). Compared to students in classroom settings, Extension clientele are usually more self-aware and focused, generally have limited expertise about a topic, are aware of deficiencies in their knowledge, and want to apply new information to solve a particular issue or challenge (Xie & Gu, 2007). To address problems and questions, Extension clientele utilize problem-solving techniques developed from previous experience and gain information from Extension programs (Xie & Gu, 2007).

The ability to leverage diverse information delivery methods enables Extension plant pathologists to appropriately deliver information and connect with different learning styles (Pouratashi & Iravani, 2012). The VARK model (visual, aural, read/write, and kinesthetic) can be used to discuss and reflect on learning styles and teaching methods (McLeod, 2006). Those with a preference for the visual mode favor information shared via images, whereas the aural mode favors information that can be heard, and the read/write mode prefers information displayed as words. Information related to experience and practice represents the kinesthetic mode (Pouratashi & Iravani, 2012). A combination of these four modes can address multimodal learning styles. The VARK model is based on the principle that different perceptual strengths should be utilized to teach material (McLeod, 2006). Previous researchers have used the VARK model to evaluate the effectiveness of podcasts as a learning aid supplement, especially for medical students (Kalludi et al., 2015; Prakash et al., 2017). Although some controversy has arisen with its use as a diagnostic tool (Husmann & O'Loughlin, 2019), it is a valuable model for considering how to vary instructional style, learning strategies, and information delivery (Fleming & Mills, 1992; Wehrwein et al., 2007).

For Extension professionals, a major benefit of utilizing podcasts for communication and education is the ability to efficiently accommodate additional learning abilities and styles. Like radio programs, podcasts focus on dialogue and are coded as an aural (A) mode of information exchange (Fleming, 1995; Pouratashi & Iravani, 2012). Additionally, podcast audiences may view the accompanying supplementary "show notes" associated with some podcast episodes. Show notes can provide podcast audiences with complementary text, hyperlinks, and/or images (MacKenzie, 2019), which can be visual (V) or read/write (R) modes of information exchange.

To meet the needs of diverse Extension clientele, the VARK model suggests Extension experts should try to use multiple modes of delivering content to accommodate multiple learning styles and meet the needs of diverse Extension clientele. An equally important consideration is whether the platform is capable of effectively and efficiently sharing technical plant pathology knowledge. To determine the value of podcasts for plant pathology programs, the researchers examined characteristics of plant pathology podcasts, modes of information delivery used, and the types of plant pathology knowledge shared.

Purpose and Research Objectives

As described above, podcasts are a popular and useful tool to share technical and scientific information, yet there is a gap in the literature on how podcasts might be used to share plant pathology information. The purpose of this study is to define the type of plant pathology information shared in podcasts and how podcasts might be utilized by plant pathology Extension programs to share information to audiences of different learning style preferences. The following research objectives guided this study:

RO 1: Identify characteristics of podcasts discussing plant pathology topics (length, release schedule, host affiliation, show genre, and production style).

RO 2: Determine how the content of podcasts align with fundamental units of plant pathology knowledge.

RO 3: Using the VARK model as a guide, investigate if plant pathology podcasts use multiple instructional strategies and information delivery modes.

Method

The researchers followed Neuendorf's (2017) guidelines for quantitative content analysis research to closely examine plant pathology related podcasts in a systematic and objective manner. Content analyses can be used to analyze any type of message format, including interactive, digital, and audio (Neuendorf, 2017; Rafter et al.2014; Yoo & Kim, 2012). The benefits of utilizing content analysis methods include its ability to take unobstructed and non-reactive measurements, include archived materials, and reduce large amounts of information into manageable units (Riffe et al., 2014). In relation to podcasts, content analysis has previously been used to evaluate blogs and discussion forums to assess the role science podcasts play in creating discussions and to evaluate the educational benefit of podcasts (Celaya, et al., 2019; Birch & Weitkamp, 2010). In this study, a podcast show is defined as a collection of podcast episodes, and a podcast episode is defined as an individual audio recording. The unit of analysis for this study is each individual podcast episode, including the audio and the written descriptions associated with specific episodes.

To identify relevant podcasts, researchers used Spotify (Stockholm, Sweden) and Apple Podcasts (Cupertino, CA, USA) because they are the most commonly used hosting applications for listening to podcasts in the United States (Statista, 2018). Researchers searched the platforms using the keywords "plant pathology," "plants," "IPM," "plant pests," "plant disease," "crops," and "plant management" on both mobile applications. The Spotify mobile application yielded 661 results, and Apple Podcasts produced 217 results when searched on March 14, 2019. After consolidating results lists and removing duplicates, 747 unique podcast shows remained. Of the 747 podcast shows, researchers removed 80 because they did not provide podcast descriptions in English. Researchers reviewed the description for the remaining podcast shows and identified each as "potentially relevant" or "not relevant" for this study. Podcast shows identified as "potentially relevant" had descriptions indicating the purpose of the podcast show as providing advice for plant care. Of the 667 remaining podcast shows, an analysis of show descriptions and names deemed 88 as "potentially relevant" for this study. Researchers discarded all other podcast shows.

An analysis of the 88 "potentially relevant" podcast shows resulted in 4,633 episodes. A review of each podcast episode description found 203 "relevant" episodes. The "relevant" episodes had descriptions indicating a potential discussion of plant pathology related content; the researchers eliminated all other episodes. The removal of six additional episodes occurred after listening to the remaining 203 episodes because they did not discuss plant pathology related content. The final sample included 197 podcast episodes spanning 40 shows. The original publication of the podcast episodes fell between July 25, 2010, and March 13, 2019.

Following content analysis best practices, the researchers summarized the details of each message set via a categorization of the content based on a codebook specific to the study (Neuendorf, 2002; Riffe et al., 2014). Prior to development of the codebook, researchers familiarized themselves with the podcast content and relevant coding categories from previous literature. Guided by the VARK model, researchers focused codebook development broadly on podcast characteristics, type of knowledge shared, and format of content to determine how a visually-driven and hands-on field like plant pathology, which often depends upon images and field work to identify plant disease, might share specific types of information in a more aural mode via podcasts. Specifically, researchers recorded podcast characteristics, such as host affiliation, podcast production level and style, schedule (both overall production status and

episode release schedule), and genre. Researchers also recorded use of show notes and fundamental units of plant pathology knowledge shared.

Pilot testing on podcasts outside of the main sample took place to refine the codebook. After finalization of the codebook, the researchers determined intercoder reliability among researchers using 10% of the total content; Krippendorff's alpha ranged from .79 to 1.0 for each element in the codebook. More details about codebook elements are below.

Host and Guest Affiliation

To determine the trustworthiness of plant pathology information shared by podcasts, we recorded the professional affiliations of podcast hosts and guests. Coders used details shared in show notes and within the podcast episode to identify highlighted and emphasized affiliations. Possible affiliations include *academic,* in which host or guest hold a degree or formal training in the topic discussed; *applied*, in which host or guest mentions having experience as a grower; c*ompany spokesperson*, in which host or guest is formally representing a company that employs them; and *unknown*, in which neither host or guest elaborate about their affiliations.

Podcast Style

Researchers based the possible values for podcast style on categories identified by PodSchool (Corbett, 2018). These categories determine the most common production styles or format followed during the podcast. These different types of podcast formats or styles follow different storytelling norms, have different production level requirements, and can build different types of relationships with listeners (Perks & Turner, 2019; Zuraikat, 2020). Extension plant pathologists and educators can utilize this information to prioritize certain production details, rather than blindly choosing production details. According to the VARK model, aural learning strategies should stress dialogue, question and answer formats, and non-formal language. Because different podcasting styles are more inclined to emphasize these strategies, it is important to look closely at the production styles used for podcasts within our sample. Categories used for analysis include s*olo style*, which included podcasts revolving around a single person directing podcast content; *co-hosted or conversational,* which included podcasts with at least two hosts who lead the conversation; *interview,* which included podcasts with a main host asking a rotating guest a series of questions; *repurposed content*, which included podcasts that reused content from other sources; and *hybrid,* which included podcasts that combined multiple styles.

Schedule

For each podcast, we recorded current production status (active, inactive for 3–12 months, inactive for more than 12 months) and episode release schedule (daily, multiple times a week, weekly, monthly, or irregular).

Podcast Genre

Researchers recorded the genre for each podcast show to evaluate the spread of plant pathology knowledge into different fields of interests, such as agriculture, cannabis, history, etc.

Knowing plant pathology's relevance to other fields can assist plant pathologists in targeting new audiences who have a predisposed interest in plant topics. The list of genres relevant for plant pathology and used in this study include *agriculture* or growing of crops and/or flowers; *gardening* or the pastime of tending and cultivating a garden; *cannabis* or the growing of and business of producing only cannabis; *history* or topics related to past impacts on plants, humans, and the environment; and *plant pathology* or discussions of the science behind plant diseases.

Units of Plant Pathology Knowledge

Information provided for farmers needs to be extensive because farmers serve the roles of producers, practitioners, and managers (Sligo & Massey, 2007). To evaluate the type of plant pathology content presented in podcasts, researchers coded each episode under one or more categories of fundamental unit of plant pathology knowledge. Researchers developed eight fundamental units of knowledge of plant pathology based on an analysis of chapter titles of 19 plant pathology textbooks and expert interviews with two faculty members of the University of Minnesota Plant Pathology department; the units can be found in Table 1. Researchers chose faculty members based on professional experience presenting the topic of plant pathology to a variety of audience groups, including the general public, undergraduate and graduate students, plant disease clinic patrons, and scientific conference attendees. Conversations with faculty members included questions such as: (a) what topics are important to include when presenting plant pathology information, and b) what are important differences in types of information presented when speaking to varied audience groups. Researchers compared information gathered from the conversations to information found in introductory plant pathology textbooks.

An evaluation of chapter titles in plant pathology textbooks determined the categorization of plant pathology information and highlighted essential units of plant pathology knowledge. Extension plant pathologists might use this information in order to determine how different fundamental units of knowledge might be approached in aural modalities, as described by the VARK model. Examining these units of knowledge also help Extension experts understand if some units of plant pathology are covered in aural modalities more than other units of knowledge.

Table 1

Definitions of Fundamental Units of Plant Pathology Knowledge

Fundamental Unit of Plant Pathology	Definition
Basics of Plant Pathology	Discussions focused on introduction to the concepts, principles, definitions, objectives, and historical and current significance of plant pathology.
Plant Pathology Techniques	Discussions about techniques used in the field, greenhouse, and lab to study plant pathology.
Biology of Plant Pathogens	Discussions about pathogenicity of plant pathogens; how plant pathogens survive, disperse, and infect plants. Includes plant-microbe interactions.
Biology of Plant Diseases	Description of the types, signs, symptoms, and life cycle of non-fungal diseases; as well as general information about specific groups of plant diseases and epidemiology.
Management and Prevention of Plant Diseases	Discussions on cultural, behavioral, physical, and chemical practices used to control or eliminate the establishment of a disease on a plant; includes plant disease resistance.
Influence of the Environment	Discussion on the effect of the environment on plant pathogens and plant diseases.
Other Causes of Plant Disease Symptoms	Discussions about abiotic agents and vectors of plant diseases.
Importance of Fungi	Description of the types, sign and symptoms, and life cycle of fungal diseases.

Note. Textbooks used to develop units authored by Agrios (2005); Barnes (1979); Bilgrami & Dude (1976); Burchett & Burchett (2018); Butler & Jones (1949); Chaube & Pundhir (2009); Chaube & Singh (1991); Gupta (2004a); Gupta (2004b); Khan (2001); Lucas et al. (1992); Mehrotra & Aggarwal (2013); Ravichandra (2013); Sambamurty (2006); Schumann & D'arcy (2009); Sharma (2004); Sharma (2006); Tarr (1972); and Waller et al. (2002).

Show Note Usage

A podcast episode can transition from a single to a multimodal form of learning and teaching by utilizing show notes. The use of show notes can make podcasts more accessible to those who are hearing impaired by providing an alternative method of retrieving information. The researchers recorded show note usage to evaluate the modes of information delivery described by the VARK model presented in podcasts with plant pathology related content. Options include *no use of show notes*, *general use of show notes* (a general description of the podcast episode), and *detailed use of show notes* (show notes include detailed information of episode, time stamps, reference links, and contact info for host and/or guests).

Results

Our results focus on characteristics of plant pathology podcasts, fundamental units of knowledge covered in plant pathology podcasts, and modes of information delivery. Each area is described in detail below.

Characteristics of Plant Pathology Podcasts

The focus of research objective one identified characteristics of plant pathology discussions in podcasts. Coders examined each podcast episode to determine the prevalence of plant pathology content and to identify basic characteristics like show length, release schedule, affiliation, production style, and genre. Collectively, 197 podcast episodes within the sample discussed plant pathology topics, totaling 118 hours and 59 minutes. These 197 episodes spanned 40 podcast shows. On average, podcast episodes discussing the topic of plant pathology made up 14% of the total number of episodes in a podcast show.

Show Length and Release Schedule

Overall, the podcasts within the study sample had a wide range of episode lengths. The average episode was 36 minutes long, which aligns with the overall average podcast length in 2019 determined by Misener (2019), but a bit longer than the average American commute time of 27 minutes (Ingraham, 2019). The shortest episode was three minutes, while the longest episode was two hours and 48 minutes. Researchers also found a wide variation in episode release schedules. Of the 40 podcast shows analyzed, 31 continued to actively publish new episodes, four shows displayed inactivity in the previous 3–12 months, and five shows displayed inactivity for more than 12 months. The most common coded release schedule for podcast episodes, irregular, had 13 shows falling into this category (see Table 2).

Table 2

Podcast Show Release Schedules

Schedule Type	Number of Occurrences	%
Daily	5	12.5
5 Episodes/Week	1	2.5
3 Episodes/Week	1	2.5
2 Episodes/Week	2	5.0
Weekly	12	30
2 Episodes/Month	3	7.5
Monthly	3	7.5
Irregular	13	32.5

Note. Release schedule coding based on the most regular release schedule for publication of podcast episodes for the entire podcast show. Percentages calculated by comparing the number of occurrences to the total number of podcast shows analyzed.

Host and Guest Affiliation

If a podcast episode included multiple guests or hosts with different affiliations, the coding of the podcast fell under multiple affiliations. This resulted in coded values for host and guest affiliation adding up to more than the total number of episodes analyzed. Twenty-seven episodes included a mixture of affiliations between the host and guests. *Ag PhD Radio* is an example of a podcast show that regularly utilizes a mixture of affiliations. An interesting insight from this research is that no individual guest or host self-identified with multiple affiliations on the podcast episodes. Although guests and hosts may have backgrounds that cross multiple affiliations, they did not verbalize it.

As seen in Table 3, the most common professional affiliation of podcast hosts and guests falls under the category of academia. This affiliation covered a wide span of academic disciplines and roles; guests and hosts in this category included plant pathologists, horticulturists, entomologists, agronomists, master gardeners, and graduate students. The applied category coded as the second most popular affiliation. Researchers found hosts and guests often described themselves (or described others) as someone who owns, owned, works, or previously worked on a farm, orchard, or vineyard. The third most common affiliation included podcast episodes spotlighting hosts or guests introduced as members of a company. Researchers found this category covered quite a few industry roles, including founder, public relations representative, president, editor, analyzer, and consultants. Companies employing these spokespersons included magazines, chemical companies, seed companies, and biotechnology companies.

The unknown category coded as the least frequently coded affiliation. Although guests and hosts coded as unknown likely had an affiliation connected to one of the other categories, they did not highlight or share this expertise within the podcast content. Interestingly, no guests or hosts identified with being self-taught.

Table 3

Frequency of Professional Affiliations of Podcast Hosts and Guests in Podcast Episodes

Affiliations	Number of Occurrences	%
Academic	151	76.6
Company Spokesperson	32	16.2
Applied	38	19.3
Unknown	13	6.6

Note. Values add up to more than 100% as a single podcast episode could be coded under multiple affiliations.

Production Style

When evaluating the types of podcasting style for each individual podcast episode analyzed, researchers coded repurposed content as the most frequently used podcasting style (115 episodes). Repurposed content mainly came from radio shows dedicated to topics such as farming, home gardening, and urban forestry. The remaining repurposed content often came from recordings of trainings, seminars, and meetings. Researchers found the style interview as the second most frequently utilized podcasting style. Only two individuals were involved in this style of podcasting: the interviewer and the interviewee. The production styles used in podcast episodes are included in Table 4.

Table 4

Frequency of Production Styles Used in Podcast Episodes

Style	Number of Occurrences	%
Repurposed Content	111	56.3
Interview	50	25.4
Co-Hosted/Conversational	16	8.1
Solo	18	9.1
Hybrid	2	1.0

Of the 40 podcast shows analyzed, all but four shows displayed consistency in their podcasting style through all podcast episodes analyzed. The podcast shows, *Plant Disease and Insect Clinic* and *Sustainable Winegrowing with Vineyard Team* used a combination of repurposed content and interview styles to create their podcast episodes. The podcast *Illini Plant and Pest* utilized a combination of the podcasting styles solo and interview. The podcast *Epic Gardening: Daily Growing Tips and Advice* employed the styles of conversational/ co-hosted and solo. In addition, two podcast episodes from *The RHS Gardening Podcast* used a hybrid of podcasting styles. Podcast producers combined audio recordings of interviews, solo conversations, and conversations between the Royal Horticultural Society employees in a single episode.

Show Genre

Podcast shows analyzed fell into five unique genres, including agriculture, gardening, cannabis, history, and plant pathology. The frequency of occurrence of genres in the podcast shows analyzed are included in Table 5. Despite three shows falling under plant pathology, only *Disease Dirt* focused solely on plant pathology. The two other podcasts coded under plant pathology are *Illini Plant and Pest* and *Plant Disease and Insect Clinic.* Although these podcasts highlighted plant pathology, they also equally highlighted other topics such as entomology, weed science, and plant injuries caused by factors other than plant pathogens. Podcasts coded the most frequently under the genre of agriculture (17 podcast shows), followed by gardening (15 podcast shows).

Table 5

Frequency of Genres Covered by Podcast Shows

Genres	Number of Occurrences	%
Agriculture	17	42.5
Cannabis	3	7.5
Gardening	15	37.5
History	2	5.0
Plant Pathology	3	7.5

Note. Genre coding based on the entire podcast show. Percentage calculating performed by comparing the number of occurrences to the total number of podcast shows analyzed.

Fundamental Units of Plant Pathology

Content analysis of the 197 episodes analyzed found discussions to cover all eight fundamental units of plant pathology knowledge. Results for the number of discussions including each fundamental unit of plant pathology knowledge in podcast episodes are in Table 6. Episodes touching on multiple fundamental units of plant pathology are coded under multiple units. A majority of podcast episodes analyzed covered multiple fundamental units of plant pathology knowledge. Only eight podcast episodes had discussions falling under only one unit.

Management and prevention of plant diseases was the most common fundamental unit of plant pathology knowledge found within our sample, with 174 podcast episodes coded as including this topic in their podcast episode discussion. The unit basics of plant pathology ranked low in occurrences for podcasts (least discussed). Typically, extension plant pathology materials are developed by focusing on a problem, generally a disease, and developing and summarizing key and relevant information about the disease to help audiences understand and manage the disease. A majority of the podcast episodes analyzed followed the same format of presenting plant pathology information. Podcast episodes discussing the fundamental unit of plant pathology of management and prevention of plant diseases mainly introduced episodes by allowing audiences to call in or write (email, social media, or website forms) and ask questions about problems (diseases) impacting their plants; helping audiences watch for certain disease signs and symptoms based on environmental conditions and time of year; and reporting disease

in a certain area and describing what to do to try to manage or prevent the disease from impacting plants.

The discussion of the topic importance of fungi appeared frequently in podcasts, which makes sense because most plant diseases are caused by fungi and fungal-like organisms (Isleib, 2012). Discussions focused on the importance of fungi within our sample included information on the different types of fungal diseases, signs and symptoms of fungal diseases, and life cycles of fungi. The high impact fungal diseases have had historically, and currently, for growers likely explains why podcast discussions focus so frequently on fungi. Similarly, the heavy influence of the environment on the incidence and severity of plant diseases likely explains the frequency of the influence of the environment in podcast episodes, coded as the third most frequently identified fundamental unit of plant pathology knowledge. Plant disease results from interactions between the host plant, pathogen, and environment.

Table 6

Frequency of Fundamental Units of Plant Pathology Knowledge of Podcast Episodes

Fundamental Unit	Number of Occurrences	%
Basics of Plant Pathology	19	9.6
Plant Pathology Techniques	38	19.3
Biology of Plant Diseases	63	32.0
Biology of Plant Pathogens	35	17.8
Management & Prevention of Plant Diseases	174	88.3
Influence of the Environment	99	50.3
Other Causes of Plant Disease Symptoms	42	21.3
Importance of Fungi	145	73.6

Note. Values add up to more than 100% as a single podcast episode could be coded under multiple Fundamental Units of Plant Pathology Knowledge.

Multimodal Information Delivery

Researchers revealed a frequent use of show notes by podcast shows in our sample. One-hundred and ten episodes of the 197 episodes utilized show notes to share general descriptions of episodes. Sixty-eight of the podcast episodes analyzed provided detailed descriptions of the specific episode. These descriptions included timestamps as an index for the episode, listed sources and references mentioned in the episode, and gave contact information or social media handles for the podcast, host, and guests for feedback and questions. The podcast show *Regenerative Agriculture Podcast* practiced detailed use of show notes. The show notes for each podcast episode started with an introduction and background information about the guest on the episode and the main topic of discussion. A synopsis of the entire conversation followed, which sometimes included timestamps for when discussions reached each topic on the episode, and the show note ended with contact information for the podcast and host for feedback and solicitation inquiries, and a plug for the host's speaking and writing engagements.

Nineteen podcast episodes did not utilize their show notes, or only used them to list the episode title. Generally, podcast shows demonstrate consistency with utilization of show notes. However, five podcast shows had a combination of detailed use and general use of show notes. See Table 7 for show note usage for podcasts included in the study.

Table 7

Frequency of Type of Show Note Usage in Podcast Episodes

Usage	Number of Occurrences	%
Not Used	19	9.6
General Use	110	55.8
Detailed Use	68	34.5

Discussion and Recommendations for Practice

The original Extension communication platform of in-person meetings has been difficult to maintain. Studies have found budget reductions, changes in clientele demographics, and an increased need for specialized education have forced Extension programs to change their structure and supplement traditional approaches of information delivery (Everts et al., 2012; Hendrickson et al., 2010). Guided by the VARK model, researchers examined if a field like plant pathology, which often relies on images and field visits to discuss plant disease, could incorporate an aural communication format like podcasts while still communicating fundamental units of plant pathology knowledge.

Researchers found a wide variety of production characteristics utilized by podcasts, some more common than others. A majority of podcasts analyzed utilized repurposed content, did identify host and guest affiliation, followed an irregular episode release schedule, and fit into the general agriculture genre. Our research questions also focused on the type of information shared in podcasts, to determine if all fundamental units of plant pathology knowledge could be shared in a more aural format. Researchers found all fundamental units of plant pathology knowledge defined by the study were discussed in podcasts within our sample. These results help us better understand the value of podcasts for Extension programs and how podcasts can be used to communicate key plant pathology information. Researchers also offer a comprehensive list of fundamental units of knowledge for plant pathology for future research. In addition, researchers found show note usage prevalent with podcasts. The use of show notes makes podcasts a valuable, multimodal communication platform that can be categorized under the visual, aural, and read/write modes of learning styles. This is a valuable insight for all types of science-based podcasts.

The VARK model is based on the premise that each person learns differently (McLeod, 2006), and previous scholarship has largely focused on using the model to determine learning style preferences of audience segments (Kalludi et al., 2015; Prakash et al., 2017). Our research findings build upon previous work by suggesting that the VARK model should also be used as a planning tool to ensure communication strategies and educational programs identify fundamental units of knowledge for their discipline and then incorporate those units across multiple modalities. Researchers also suggest that podcasts might be using a variety of production formats, with some production styles more prone to incorporate aural strategies like dialogue and

chit-chat than others, which should be considered by researchers using the VARK model to examine the effectiveness of podcasts on different learning styles.

Extension programs should consider using podcasts and detailed show notes to meet diverse learning preferences. Podcasts can help meet multiple needs of Extension programs, such as the ability to engage different audiences while still meeting needs of current clientele, meet the demand for online resources, and cater to a variety of learning styles (Plastina et al., 2019). This is an important insight for fields like plant pathology that tend to rely heavily on visual and kinesthetic learning. As audiences of plant pathology increase and diversify, so does the need for different types of communication platforms and learning styles. Our findings help shape a set of recommendations for those considering using podcasts to share plant pathology information.

Recommendation 1: Use Fundamental Knowledge Units to Guide Podcast Planning

With podcasts growing in popularity and few shows discussing plant pathology, it is advantageous for plant pathology Extension programs to produce plant pathology related podcasts while the market is unsaturated. Our research reveals there is likely a listener base for plant pathology content, with 40 podcast shows discussing this topic and 31 still actively publishing new episodes. Basic plant pathology knowledge can be incorporated into podcasts that take a broad approach, for example, shows which also cover general agricultural issues or gardening topics. Extension experts might consider partnering across Extension groups to produce podcasts that fit these broader genres.

The 197 podcast episodes analyzed collectively covered all of the fundamental units of plant pathology knowledge, which indicates it is possible to use podcasts to give listeners a wide base of plant pathology information, to scaffold learning for listeners, and to target technical information to specific audience segments. The sample of podcasts discussing the fundamental units of plant pathology knowledge analyzed in this study can be utilized by plant pathologists as a guide for how to format podcast shows and episodes. For example, a broad gardening podcast show or one focused on more general agricultural issues, might address basics of plant pathology and a general overview of the biology of plant diseases and biology of plant pathogens. Because growers are directly affected by these issues and can implement control recommendations for diseases, information on management and prevention of plant diseases is a more critical focus for this audience, with references in the show notes to more foundational knowledge, if needed.

In addition, it is of value to closely examine how different podcasts approached the management and prevention of plant diseases topic, as technical information that falls into this category is typically the central focus for most Extension plant pathologists and their clientele. Extension plant pathologists and clientele will still be able to communicate and interact with each other about the same issues utilizing the current communication platforms they have used, however, incorporating podcasts into interactions could provide added benefits and deepen learning on technical topics. This supports research Raupach et al. (2015) and Back et al. (2017) published about podcasts providing medical students better knowledge acquisition and retention and higher satisfaction from learning compared to learning the same content via traditional lectures and books. With podcasts on the topic of management and prevention of plant diseases, Extension clientele have the ability to go back and review all, or parts, of the shared information. Extension clientele may want to review management and prevention information during the off-season to prepare for an upcoming growing season. The ability to review a podcast at any time also provides Extension clientele with the ability to pick up important missed details. Because of

the portability of podcasts, they could be brought into the field or greenhouse and used as an additional source of reference for clientele and their employees to utilize when determining how to manage or prevent a plant disease.

The information found in this study can also assist Extension plant pathologists in determining existing information gaps in plant pathology knowledge shared. It might be useful for Extension plant pathologists to develop general content to fill gaps found in the fundamental units of plant pathology knowledge of basics of plant pathology, biology of plant pathogens, and plant pathology techniques, or generate a list of other references to share within their podcast audience. New podcasts discussing plant pathology related topics can leverage the most frequently discussed fundamental units of plant pathology knowledge and transition to discussions that include remaining fundamental units of knowledge, thereby creating a deeper and more accurate understanding of plant pathology for growers and other audiences.

Recommendation 2: Repurpose Content

Extension plant pathology programs could start publishing podcast episodes with minimal effort by repurposing content from other events and programming. The utilization of recorded plant pathology Extension programming to create podcast episodes is beneficial. For the clientele, repurposed content provides the opportunity to review programming content at their own convenience, pace, and without environmental distractions that come with learning in a live setting, while still meeting the needs of aural learners as defined by the VARK model. This type of content repurposing also meets the needs of traditional Extension audiences who prefer a combination of self-delivery and traditional delivery, such as in-person events. Additionally, repurposed content could benefit extension clientele who miss programming because of overlapping sessions or the inability to attend an event. The use of repurposed content in podcasts allows for uniform education for audiences without the added struggles of trying to balance learning, work, and personal life (Malan, 2007; Shekarchi et al., 2018; Wolpaw & Toy, 2017). Although most Extension events are dependent on visuals, the ability to replay audio from an extension event may be enough to jog a memory about a specific topic or guide some in the right direction to resources or further assistance. The use of repurposed content from live Extension events in podcasts which utilize show notes also benefits attendees of live events who prefer the VARK model learning style of read/write.

For Extension plant pathologists, repurposed content could provide multiple benefits, including the ability to double dip and increase communication effectiveness and efficiency. A single communication platform, such as a field day or lecture, can transition into two different communication platforms by recording the audio from the event and repurposing it as a podcast episode. A second benefit of utilizing repurposed content is the ability to reach new and current audiences. An Extension event may be targeted toward a specific group of growers, however, when the content is repurposed and published as a podcast episode, someone from outside of the targeted audience group may benefit. Listeners of the repurposed content will also have a better idea of what types of information are presented at plant pathology Extension events and how the information is shared, potentially making them more inclined to register and attend future events or share this information with their networks.

Recommendation 3: Use Podcasts to Expand Voices and Affiliations of Experts

The bulk of podcast episodes analyzed (76.6%) had hosts and/or guests with academia affiliations. The high level of involvement from academic experts is promising and beneficial for listeners because they can feel confident the content is likely accurate and reliable. Information shared by company spokespersons may contain underlying bias, as it is likely shared to benefit the company. Some podcast episodes included hosts and multiple guests with different professional affiliations, which would be valuable for plant pathology Extension programs, as it would expand perspectives, expertise, and motivations for sharing information. The collaboration between diverse host and guest affiliations also helps plant pathology Extension programs to introduce themselves to new listeners and expand the program's audience base.

Recommendation 4: Leverage Show Notes When Producing Podcasts

Show notes are beneficial for Extension plant pathologists and Extension clientele. Extension plant pathologists can use show notes to assist with the discussion of proper identification of plant diseases by linking to images and diagrams, which is important for a visually driven field like plant pathology. Show notes are also beneficial for Extension plant pathologists because they can include links to other Extension resources, thereby driving podcast listeners to other sources of information created by plant pathologists. Episodes in this study included blogs, Extension pages, videos, and other reference websites in show notes.

Show notes allow podcasts to address learning styles identified by the VARK model of audio, visual, and read/write, and in turn, accommodate multiple types of learning. Although it is impossible to cater to the needs of every audiences' learning style, creating podcasts and including transcripts and links to images, videos, and other written work in show notes increases the odds of meeting audience learning needs described in the VARK model.

Show notes can also provide additional resources to Extension clientele regarding a specific topic, allow clientele to "skim" an episode, provide a transcript for those who may be hearing impaired, and help audiences follow-up with Extension plant pathologists. Researchers found show notes share extensive and detailed information, including timestamps for the episode, links to other relevant resources, and a transcript of the episode. Extension plant pathologists should carefully consider what to include in their show notes and can refer to the podcasts analyzed in this study for ideas and models.

Limitations and Recommendations for Future Research

Future research should include a larger pool of podcast shows and episodes to analyze by utilizing additional search keywords and including podcasts in languages other than English. Researchers focused only on available content for audiences, but not what the audiences of plant pathology podcasts want to hear or how effective podcasts are for plant pathology information compared to other types of communication platforms. We recommend future researchers consider examining wants and needs of plant pathology podcast audiences to provide deeper insight into benefits and optimal use of podcasts for Extension plant pathology programs. We also recommend that future researchers analyze what audiences are learning from podcasts, compared to other communication channels.

A potential challenge for plant pathology Extension programs, and one that could benefit from additional research, is how to best introduce and gain acceptance of new methods of learning. Anecdotal evidence from fruit and vegetable growers in the Upper Midwest indicated

an interest in receiving information via podcasts; even though in a survey, growers ranked podcasts at the bottom of a list of educational tools they are likely to use. The discrepancy between word of mouth and survey results could be caused by the wording used within the survey question or because other Extension program communications platforms (such as websites, field days, etc.) are more abundantly available than podcasts (A. Klodd, personal communication, October 7, 2019). Although a study of dairy podcasts by the Industry and Investment NSW found podcasts to be a useful tool for future Extension programs because of acceptance by their clients (Mills, 2011), extra effort may be required to promote and advertise podcasts when first introduced to extension clientele. Training may be required at the onset of a podcast to demonstrate what a podcast is and how they are accessed. More research on podcasts could also determine if audiences actually listen to downloaded episodes of a podcast.

An additional concern with utilizing podcasts for agricultural Extension is the amount of time it takes to produce and distribute the podcasts to audiences. Many people can readily acquire the skills necessary to develop and deliver podcasts (Mills, 2011). Podcasts can be created with a microphone, audio recording and editing software, and a web hosting service; or with just the use of a smartphone (MacKenzie, 2019). Yet, producers of *Soybean Podcast Alerts* noted initial challenges and improvements in the production experience gained after training (Norman, 2010). Additional research on general science communication training needs and knowledge of podcast production among Extension experts would also be valuable.

Conclusion

The researchers aim to take the first step forward in evaluating podcasts for Extension plant pathology use. The most important consideration Extension plant pathology programs should make when developing content is how to communicate the essential information in a manner that best suits their audiences (Plastina et al., 2019). The ability to provide content in desirable formats for audiences is valuable (Everts et al., 2012; Hendrickson et al., 2010). As podcasts continue to grow in popularity, Extension plant pathology programs must explore the potential uses of podcasts in their programs to continue to provide vital information in a timely manner and as conveniently for their audiences of all learning styles as possible. Researchers hope to highlight that podcasts offer significant potential for use in plant pathology Extension programs. Podcast usage for plant pathology programs can help alleviate problems related to funding shortages, accommodate multiple learning styles and needs, and address limitations associated with meeting in person at a specific time and location.

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