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Geographical Distribution and Causal Agents of Chile Pepper Wilt in New Mexico

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SUMMARY

Diseases with wilt symptoms are commonly encountered in chile pepper fields in New Mexico. Field surveys were conducted from 2002 to 2004 to assess the geographical distribution and causal agents of chile pepper wilt. Over the three-year period, 59 fields were surveyed with 8, 20, and 72 percent of fields in north-central (Rio Arriba county), southeastern (Chaves, Eddy and Lea counties), and southwestern (Doña Ana, Hidalgo, Luna, and Sierra counties) New Mexico, respectively. All fields surveyed had plants exhibiting wilt symptoms, and affected areas varied from less than 3 percent to over 80 percent of total field. Based on field examination, symptoms of diseased plants were characteristic of infection by *Phytophthora capsici* and *Verticillium dahliae*. Absence of root rot accompanied by vascular necrosis in the root or stem was used as an indicator of infection by *Verticillium dahliae*. Infection by *Phytophthora capsici,* or organisms other than *V. dahliae,* was gauged by the presence of root rot and root sloughing with or without lower stem lesions. Symptoms of plant infection by *V. dahliae* were found in 80 percent of the fields, whereas symptoms of plant infection by *P. capsici* were encountered in 100 percent of the fields. Symptoms of both pathogens were present in 80 percent of the fields, and symptoms of co-infection (both pathogens in the same plant) were found in 12 percent of the fields. Under laboratory conditions, *V. dahliae* was the only microorganism isolated from stems of plants exhibiting vascular discoloration, and *P. capsici* was the microorganism isolated with the highest frequency from plants with root rot. Both *P. capsici* and *V. dahliae* recovered from diseased plants caused wilting when inoculated onto chile pepper plants under greenhouse conditions, thereby confirming they were the cause of wilt symptoms in field-grown plants. This study indicates that *P. capsici* and *V. dahliae* are well established in chile pepper production fields in New Mexico, and that effective management of wilt on chile pepper needs to focus on both pathogens.

BACKGROUND AND JUSTIFICATION

Producers of chile pepper in New Mexico are confronted with several constraints including diseases and pests. A survey of production practices and problems administered to chile pepper producers in 2000 indicated that wilt diseases are the most frequently encountered problem (Skaggs et al., 2000) in New Mexico. Wilt diseases have been studied at various times in New Mexico since the beginning of the 20th century (Leonian, 1919 and 1922; Smith, 1961), and these diseases have been attributed to several microorganisms including species of *Fusarium, Phytophthora and Verticillium.*

There is an undocumented consensus within the chile industry that Phytophthora blight caused by *Phytophthora capsici* is the most prevalent disease problem in chile pepper production fields in New Mexico. However, there have been no system-

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atic studies to appraise the distribution, etiology and incidence of wilt diseases in production fields within the state. Such studies would provide useful information on the geographic distribution and seriousness of wilt symptoms and their causative agents.

Effective management of a plant disease is predicated upon an accurate characterization of its causal agents and their spatial distribution. Information on geographical distribution will aid in decisions on crops and cultivars to be planted to prevent or reduce the devastating effects of wilt-causing pathogens. The characterization of microorganisms associated with wilt will benefit producers as well as researchers engaged in breeding programs to develop and deploy wilt-tolerant cultivars.

The work reported here was conducted to provide an updated appraisal of the status of wilt diseases on chile pepper in New Mexico.

MATERIALS AND METHODS

Field sampling

In the growing seasons of 2002, 2003 and 2004, fields of chile pepper were surveyed for incidence of wilt in several counties in north-central, southwestern and southeastern New Mexico. Over the three-year period, 59 fields were surveyed with 8, 20, and 72 percent of fields in north-central, southeastern and southwestern regions, respectively. The percentage of fields surveyed reflects the importance of chile production in each region. Chile pepper production is concentrated primarily in the four counties surveyed in the southwestern region (Doña Ana, Hidalgo, Luna, and Sierra), which accounted for approximately 93 percent of production in 2003 (NMDA, 2004). In the same year, the three counties surveyed in the southeastern region produced about 5 percent of the chile pepper harvested, and the remaining 2 percent of the production was contributed by several counties in central and northern areas of the state (NMDA, 2004).

Chile pepper plants were sampled at growth stages from green fruit to beginning red fruit during the survey. Plant samples (from 5 to 25 wilted plants) were arbitrarily selected and uprooted at 5 to 10 spots in each field. Plants with wilt symptoms were sampled by walking along W-patterns through the middle of fields less than 2 hectares or by driving around larger fields. The method of irrigation used in each field was recorded.

Field diagnostics

Based on the literature of diseases with wilt symptoms on pepper (Pernezny et al., 2003), symptoms observed were ascribed to specific pathogens. To separate wilt due to *Verticillium dahliae* from wilt due to *Phytophthora capsici,* we used the following criteria. Absence of root rot accompanied by vascular necrosis in root or stem was used as an indicator of infection by *Verticillium dahliae.* Infection by *Phytophthora capsici,* or microorganisms other than *V. dahliae,* was gauged by the presence of root rot and root sloughing with or without lower stem lesions. The percentage of field area exhibiting wilt symptoms was estimated. The incidence of wilt symptoms caused by *P. capsici, V. dahliae,* or both pathogens was defined as the percentage of plants with symptoms characteristic of *P. capsici, V. dahliae,* or both pathogens, respectively.

Laboratory diagnostics

Three plants with root rot and three plants with vascular necrosis were taken from each field visited and further processed in the laboratory to confirm field diagnostics. Four 1-centimeter segments were cut from the base of each stem and from the upper part of the tap root for each plant. Thus there were 12 stem segments and 12 root segments sampled from each plant. Root and stem parts were washed to remove soil, surface disinfested for 2 minutes in 0.5 percent sodium hypochlorite, rinsed in sterile distilled water, and plated onto water agar medium in 9-centimeter diameter petri plates. Mycelial colonies emerging from the plated segments were identified based on morphological characteristics and microscopic observations. The number of segments from which *V. dahliae* and *P. capsici* were recovered was recorded and the percentage of isolation (frequency) of these two pathogens was computed. The percentage of recovery of mycelial colonies other than those from *V. dahliae* and *P. capsici* was also computed. Pathogenicity tests were conducted under greenhouse conditions to assess the ability of isolated microorganisms to cause wilt on chile pepper.

RESULTS

A. Incidence of wilt across all regions

Fifty-nine fields were surveyed over the 3-year period of the study from 2002 to 2004. Of these 59 fields, 54 were furrow-irrigated, four were drip-irrigated, and one was sprinkler-irrigated. The proportion of total field area with wilt symptoms varied from less than 1 percent to 90 percent with an average of 15 percent. Based on field diagnostics, symptoms of plant infection by *V. dahliae* were found in 80 percent of the fields, whereas symptoms of plant infection by *P. capsici* were encountered in 100 percent of the fields (fig. 1). Symptoms of plant infection by both pathogens were present in 80 percent of the fields, and symptoms of co-infection (both pathogens found in the same plant) were observed in 12 percent of the fields.

When wilt symptoms were examined with regard to irrigation type over all regions, average field area with wilted plants was less than 3 percent in fields under drip irrigation, and approximately 15 percent in fields under furrow irrigation. Incidence of *P. capsici* in sampled plants was approximately 40 percent less ($P (> t) = 0.045$) under drip irrigation than under furrow irrigation (fig. 2). Conversely, incidence of *V. dahliae* in sampled plants was about 32 percent greater under drip irrigation than under furrow irrigation, even though statistical significance (at $P = 0.05$) for this difference was not indicated due to high variability ($P (> t) = 0.1608$).

Incidence of wilt by region and county

In counties surveyed in the southwestern part of the state (Doña Ana, Hidalgo, Luna, and Sierra counties), the proportion of total field area with wilt symptoms varied from less than 3 percent to 90 percent with an average of 18.5 percent. Average incidence of wilt caused by *P. capsici* was 40 to 83 percent (fig. 3), and the disease was found in all fields. Symptoms of plant infection by *V. dahliae* were found in 85 percent of the 42 fields surveyed, and average incidence of the disease in sampled wilted plants varied from 23 to 58 percent (fig. 4). Both *P. capsici* and *V. dahliae* were found in 85 percent of the fields. Plants displaying symptoms of co-infection with *V. dahliae* and *P. capsici* were found in 20 percent of the fields, with incidence ranging from 7 to 20 percent.

In southeastern New Mexico (Chaves, Eddy and Lea counties), the proportion of total field area with wilted plants ranged from less than 3 percent to over 20 percent with an average of 5 percent. Symptoms of plant infection by *P. capsici* were encountered in all 12 fields surveyed, with average incidence in sampled wilted plants ranging from 82 to 90 percent (fig. 3). Conversely, symptoms of plant infection by *V. dahliae* were found in 58 percent of fields, with average incidence spanning from 18 to 50 percent (fig. 4). Both *P. capsici* and *V. dahliae* were encountered in 58 percent of the fields. No plants were found displaying symptoms of co-infection with *V. dahliae* and *P. capsici*.

In Rio Arriba county (north-central part of the state), the proportion of total field area with wilted plants was generally small (less than 1 percent). Symptoms of plant infection by *P. capsici* were found in all five fields, with average incidence in sampled wilted plants of 48 percent (fig. 3), and a range from 20 to 100 percent. About 80 percent of the fields had plants with symptoms characteristic of infection by *V. dahliae*, with average incidence in sampled wilted plants of 65 percent with a range from 50 to 80 percent (fig. 4). Both *P. capsici* and *V. dahliae* were encountered in 80 percent of the fields. No plants were found displaying symptoms of co-infection with *V. dahliae* and *P. capsici*.

Isolation and identity of microorganisms from stems and roots

Several microorganisms were isolated from wilted plants and include *V. dahliae, P. capsici, Rhizoctonia solani,* and species of *Fusarium, Penicillium, and Aspergillus.* The only microorganism isolated from stem segments was *V. dahliae,* and the microorganism isolated from root segments with the highest frequency was P. capsici. Therefore pathogenicity tests were conducted only for isolates of these microorganisms. The ability of isolates of *V. dahliae* and *P. capsici* to cause wilting was tested in the greenhouse on the chile pepper cultivar New Mexico 6-4, which is known to be susceptible to both pathogens. Seedlings were inoculated at the 6- to 8-leaf growth stage with zoospore suspension of each *P. capsici* isolate or conidial suspension of each *V. dahliae* isolate using procedures outlined by Sanogo (2006) and Sanogo and Clary (2003). Non-inoculated seedlings were included as controls.

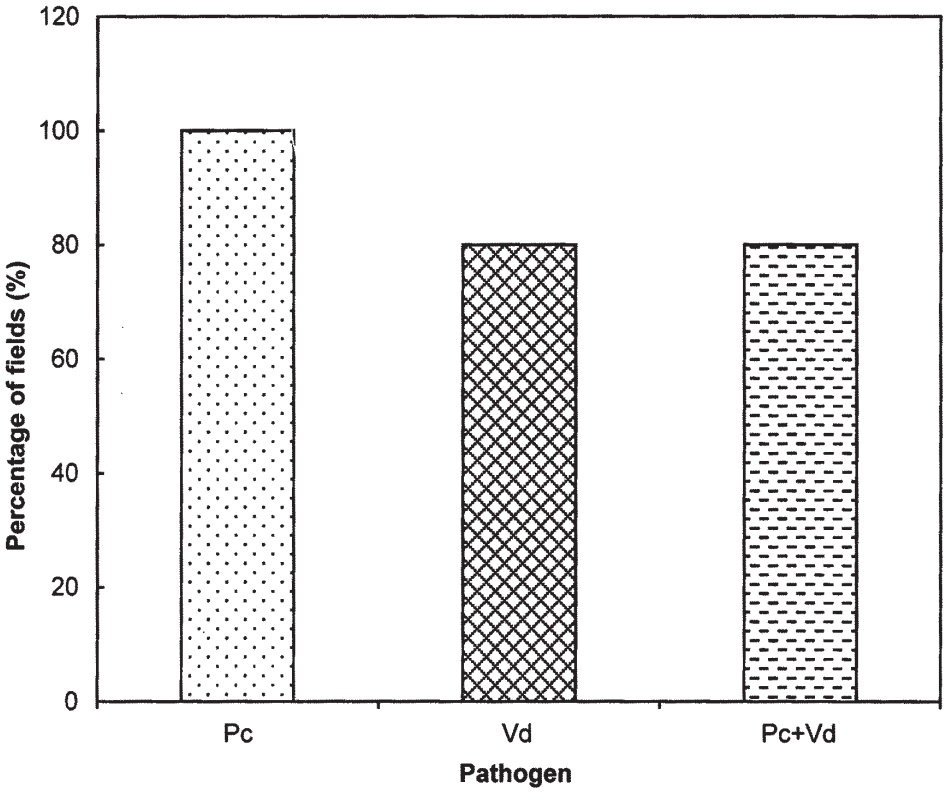

Figure 1. Percentage of fields surveyed with symptoms of infection by *Phytopthora capsici* (Pc), *Verticillium dahliae* (Vd), and both pathogens (Pc+Vd).

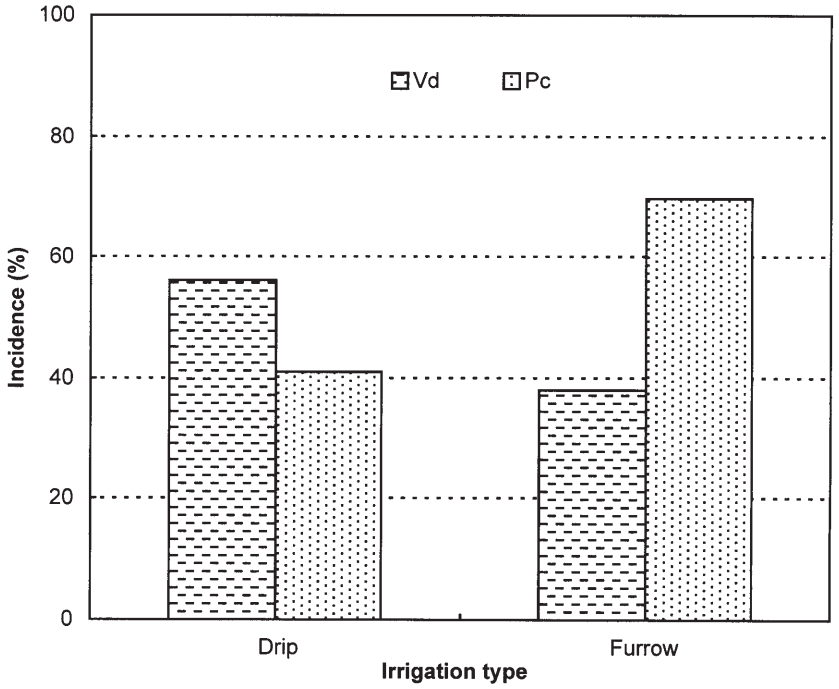

Figure 2. Incidence of wilted plants with symptoms of infection by *Phytopthora capsici* (Pc), and *Verticillium dahliae* (Vd) in fields under drip and furrow irrigation.

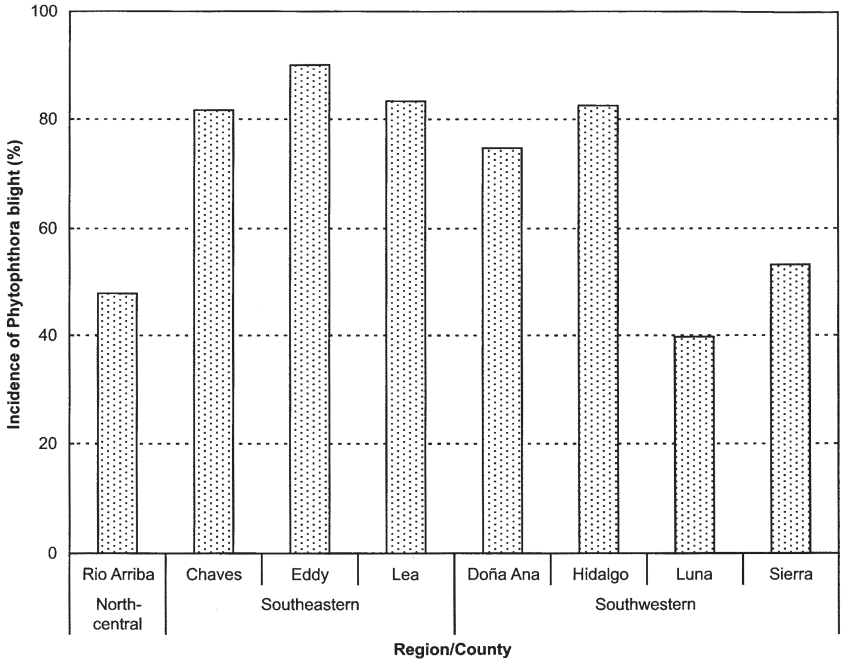

Figure 3. Incidence of wilted plants sampled with symptoms of Phytophthora blight from fields surveyed in counties from north-central, southeastern, and southwestern New Mexico.

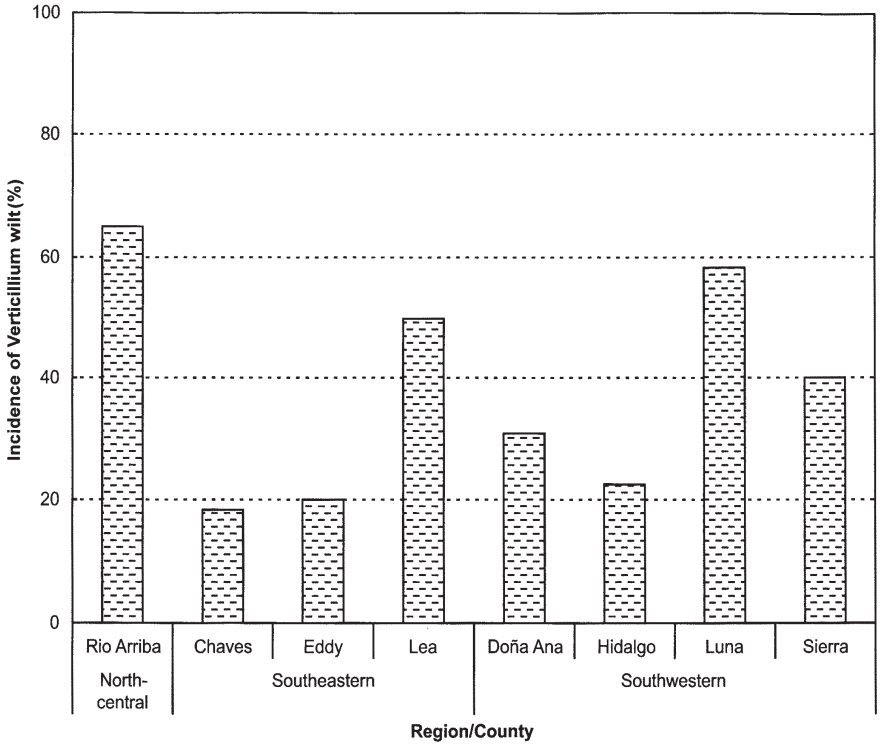

Figure 4. Incidence of wilted plants sampled with symptoms of Verticillium wilt from fields surveyed in counties from north-central, southeastern, and southwestern New Mexico.

Ten isolates each of *P. capsici* and *V. dahliae* were tested, with 2, 3 and 5 isolates from north-central, southeastern, and southwestern parts of the state, respectively.

Wilting and vascular necrosis were observed within 6 to 8 weeks in plants inoculated with each of the 10 isolates of *V. dahliae*. Girdling or non-girdling stem lesions accompanied by root rot and wilting appeared within 10 to 14 days in plants inoculated with P. capsici. Thus, all isolates of *V. dahliae* and *P. capsici* used were proven to be pathogenic.

Recovery of *Verticillium dahliae* from weeds

Verticillium dahliae was recovered from several weeds during the course of this study. The ability of *V. dahliae* recovered from weeds to infect chile pepper cultivar New Mexico 6-4 was tested for three weed species (Sanogo and Clary, 2003): Wright groundcherry (*Physalis wrightii*), spurred anoda (*Anoda cristata*), and devil's-claw (*Proboscidea louisianica*). The isolates of *V. dahliae* from these weeds caused wilting and vascular discoloration in chile pepper similar to symptoms encountered under field conditions.

DISCUSSION AND CONCLUSION

This is the first known systematic field survey of diseases with wilt symptoms in commercial chile pepper production fields in New Mexico. The study showed that wilt is widely distributed throughout the chile pepper growing areas, and both *P. capsici* and *V. dahliae* were associated with wilt symptoms. *V. dahliae* was the only microorganism isolated from stems displaying vascular necrosis, and *P. capsici* was the microorganism isolated consistently with the highest frequency from root segments with rotting and sloughing symptoms. Additionally, these pathogens recovered from wilted plants were tested and demonstrated to be pathogenic on susceptible chile pepper.

The ability of isolates of *V. dahliae* from weeds to infect chile pepper indicates the potential of weeds to perpetuate and increase populations of *V. dahliae* in cultivated fields. One implication of this study is that weed control is crucial in management of *V. dahliae* in chile pepper or in other susceptible rotational crops. This study also indicates that *P. capsici* and *V. dahliae* are well-established in chile pepper production fields in New Mexico, and that effective management of chile pepper wilt needs to focus on both pathogens.

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