Original article

A description of the progression of stip, a reputed physiological disorder, in two pepper (*Capsicum annuum* L.) cultivars grown in a greenhouse

J.C. Fulton¹, R. Steiner², J.C. Colee³ and M.E. Uchanski⁴

¹ Plant Pathology, University of Florida, Gainesville, U.S.A.

² Economics, Applied Statistics, and International Business Department, New Mexico State University, Las Cruces, U.S.A.

³ Statistical Consulting Unit, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, U.S.A.

⁴ Horticulture and Landscape Architecture, Colorado State University, Fort Collins, U.S.A.

Summary

This study reports the occurrence of stip symptoms in two pepper cultivars grown in a greenhouse setting. We describe the temperature, PAR, watering, and fertilization conditions under which stip symptoms developed. Others have concluded that nitrogen and light-limited conditions are essential contributors to stip manifestation. In contrast, we did not limit light in this experiment, and symptoms still developed under natural day length and light conditions. We also quantified cultivar susceptibility differences in terms of incidence and severity, as well as harvest-to-harvest and year-to-year differences. Furthermore, we characterized the location of symptomatic pods on the plant for the first time.

This study demonstrates that stip can develop under greenhouse conditions, describes underlying greenhouse conditions under which stip symptoms developed, generates baseline incidence and severity levels in a greenhouse environment for two different pod-type peppers, and describes the location of symptomatic pods as well as a progression over time.

Keywords

abiotic stress, 'AZ 1904', black spot, 'Cal Wonder 300', color spot, environmental stress, lime soil

Summary

Stip is a presumed physiological disorder that causes discolorations on pepper fruit, rendering them unmarketable but otherwise healthy (Figure 1). While this disorder is not believed to be the result of any biological cause, the environmental conditions responsible for symptom expression have not been determined. Furthermore, few studies have been conducted under controlled greenhouse growing conditions, and no previous studies have examined New Mexican pod-type peppers' susceptibility to stip. Therefore, the objectives of this work were to 1) determine if stip symptoms can be produced in a greenhouse; 2) characterize the conditions under which symptoms developed; 3) evaluate the susceptibility of a New Mexican pod-type cultivar and a bell pod-type in a greenhouse; and 4) outline methods to describe symptom expression and progression of the disorder. Data collection included the number of symptomatic plants (incidence), the number of symptomatic pods per plant (se-

Significance of this study

What is already known on this subject?

- Stip is a reputed physiological disorder of particular pepper (*Capsicum annuum* L.) cultivars and pod types. Symptoms present as discolored lesions from the surface of pods into the internal tissue of developed fruits.

What are the new findings?

- Symptoms consistent with those described as stip were produced during two consecutive years under controlled greenhouse conditions.
- Symptom expression, including the location of symptomatic pods and lesions, was described in plants harvested similarly to those commercially cultivated in the field.
- The 'Cal Wonder 300' bell pepper cultivar, previously reported as moderately resistant to stip, showed consistently lower incidence and severity levels than 'AZ 1904', a New Mexican pod-type cultivar.

What is the expected impact on horticulture?

- This study helps establish baseline environmental greenhouse conditions under which the appearance of stip symptoms occur in two commercially important pepper pod types.
- This study also serves as a preliminary step in developing protocols to screen stip susceptibility in peppers, possibly for breeding programs to select resistant cultivars.

verity), the number of lesions per symptomatic pod, and the location of symptomatic pods as the plant developed under greenhouse conditions. Two harvests were conducted for each of the two experimental years to simulate commercial practices of the early and late-season hand harvests. During the study's first year, both cultivars showed relatively high levels of stip incidence and severity. A significant difference in incidence between cultivars was detected; lower levels of incidence were observed in 'Cal Wonder 300' ($p=0.032$). This observation was noted again during the second year as pods from 'Cal Wonder 300' had fewer lesions, and incidence was significantly lower compared to 'AZ 1904'. Both cultivars showed a similar pattern of the symptomatic pod and lesion distribution. At the first harvest, lesions were typically found

from nodes 1–4 and progressed to nodes 5–9 by the second harvest. In summary, stip symptoms developed during two consecutive years in a greenhouse setting, and the conditions under which these symptoms developed are described here.

Introduction

The physiological disorder known as stip causes unsightly internal and external spots on pepper fruits without apparent symptoms on other plant parts (Seminis, 2017). Stip lesions are black, yellow, or green and approximately 1.3 cm in length and 0.6 cm in width. Lesions most noticeably affect mature red pepper fruits; however, they are also apparent in immature green fruits (Fulton and Uchanski, 2017; Figure 1). Reported losses from stip are between 25% and 67%, depending on the year (Fulton and Uchanski, 2017). Bacterial, fungal, and viral pathogens have been ruled out as causal agents, yet no specific environmental condition is implicated as a contributing factor (Hibberd, 1981; Villalon, 1975). Temperature extremes (e.g., cool temperatures during fall harvest or high temperatures between 30°C to 35°C during fruit set) have been observed in some cases (Wien and Zitter, 2003). Consequently, the development of stip lesions on pepper fruits is generally regarded as the consequence of an unknown or undefined abiotic stress.

Eijsinga et al. (1973) and Villalon (1975) were the first to document pepper stip; their work provides a general description and observation of the disorder. There are a relatively small number of additional published studies, but only a few of those were conducted under greenhouse conditions (Aloni et al., 1994; Carroll, 1979; Eijsinga et al., 1973; Fulton and Uchanski, 2017; Smith et al., 1999; Stolk and Maaswinkel, 1977). All greenhouse studies examined symptom development in bell peppers, but none included other pod types. Past greenhouse studies did not detail the conditions under which symptoms appeared, describe the locations of symptomatic pods and lesions on individual plants, or record stip severity.

In a greenhouse study, Eijsinga et al. (1973) observed that symptomatic tissue had an elevated concentration of calcium compared to asymptomatic tissue, and there was an increase in severity in plants grown in soil with an elevated level of calcium carbonate (active ingredient in agricultural lime soil amendment). Using bell pepper samples collected

from the Lower Rio Grande Valley of Texas, Villalon (1975) attempted unsuccessfully to isolate a causal organism and concluded that a biotic agent was not responsible for stip symptom manifestation. Aloni et al. (1994) and Carroll (1979) attempted to elucidate the underlying abiotic causes leading to the development of stip symptoms in several bell pepper cultivars. Feigin et al. (1987) reported that plants that did not receive nitrogen fertilization were asymptomatic; however, symptom incidence increased when a corresponding increase in nitrogen fertilization, greater than that required for physiological demands, was applied.

Furthermore, through a series of experiments conducted in the greenhouse, Aloni et al. (1994) concluded that excess nitrogen and limited light conditions were essential contributors to stip manifestation. They proposed that excess nitrogen fertilization resulted in physiological stress when plants were unable to accumulate additional photoassimilate in proportion to the increased nitrogen content. The resulting physiological stress caused by a nitrogen-photoassimilate imbalance was then exacerbated during conditions of limited light. Carroll (1979) evaluated the impact of lime soil amendments and reported a correlation between lime soil amendments and an increased prevalence of the disorder.

One management approach used to minimize stip is to select cultivars that are less likely to develop symptoms under field conditions. Commercialized hybrid lines or the open-pollinated 'Cal Wonder 300' bell pepper cultivar are reported to show moderate stip resistance (Smith et al., 1998, 1999). Bell pepper pod-type cultivars are relatively well represented in the existing stip literature (Fulton and Uchanski, 2017), but New Mexican pod-type cultivars (Figure 1) have not been formally studied. 'AZ1904' is a pungent New Mexican pod-type pepper that has been reported by commercial growers and processors to be susceptible to stip during high summer temperatures (B. Etcheverry, pers. commun.), but this observation has not been validated.

Therefore, the objectives of this work were to 1) determine if stip symptoms observed in the field can be produced in a greenhouse; 2) characterize the conditions under which symptoms developed; 3) evaluate cultivar and pod type susceptibility differences in a greenhouse trial; and 4) outline new methods to describe symptom expression and progression of the disorder.

FIGURE 1. Field-grown New Mexican pod-type pepper, 'AZ1904,' cultivated during the 2014 growing season showing stip symptoms (circled in red; bar length = ~7 cm). Figure modified from Figure 1A (Fulton et al., 2017).

Materials and methods

An experiment was established to evaluate the susceptibility of 'AZ 1904' (New Mexican pod type, Figure 1) and 'Cal Wonder 300' under greenhouse conditions in 2014 and 2015 (Feb.–Sep.). The experiment was arranged as a completely randomized design (CRD) with individual potted pepper plants as experimental units. Each cultivar was represented by 13 pots in year one and 15 to 16 pots in year two.

Seeds of the two pepper cultivars were sown at a depth of approximately 1.25 cm in 25.4 cm × 50.8 cm plastic inserts filled with general purpose potting medium (LM-3 All Purpose Mix, Lambert, Québec, Canada) and irrigated by hand daily until emergence. Once the seedlings developed their first set of true leaves, a plug from the cell was transplanted into approximately 2.51 L pots between 21 Mar.–12 Apr. and later into 8.7 L pots between 31 May–5 Jun. Individual plants were relocated during each transplanting date to compensate for the physical structure of the greenhouse and the non-uniform light conditions.

In year one, pepper seeds were sown between 13–14 Feb., using purchased 'Cal Wonder 300' seeds (W. Atlee Burpee & Co., Warminster, PA). 'AZ 1904' self-pollinated seeds were obtained by transplanting and maintaining symptomatic field-grown plants to a greenhouse until seed production (Curry Chile and Seed Co., Pearce, AZ). Seeds were then harvested and used as planting material for both the first- and second-year cultivations. In year two, 'Cal Wonder 300' and 'AZ 1904' seeds were sown on 12 Feb.

Plants were watered to container capacity early each morning. On 13 Apr. and 12 Aug., 240 mL of a 20-20-20 N-P₂O₅-K₂O water-soluble fertilizer with micronutrients (22 mL 3.8 L⁻¹) was applied (Nursery Select Plant Food, Scotts Miracle-Gro Co., Marysville, OH). A 20-20-20 water-soluble fertilizer solution with micronutrients (14.8 mL 3.8 L⁻¹) and 5 ppm iron was also applied on 12 May. In both years, between 16–20 May, 15 g per pot of 14-14-14 N-P₂O₅-K₂O slow release, water-soluble fertilizer pellets (Osmocote, Scotts Miracle-Gro Co., Marysville, OH) were applied to the soil surface. In year one, spirotetramat insecticide (5 mL 3.8 L⁻¹, Bay-

er, Leverkusen, Germany) was applied on 1 Jul. and 10 Jul. to control aphids. During year two, insecticidal soap was spot sprayed on 10 Jun. and 16 Jun. (Insecticidal Soap Insect Killer, Spectrum, Madison, WI) for aphid control. This soap was followed by spirotetramat insecticide (5 mL 3.8 L⁻¹ Movento, Bayer, Leverkusen, Germany) on 24 Jun.

Greenhouse temperature set points were programmed at 14.4°C (low) and 28.3°C (high). Temperature controls were disabled the morning of 1 Jul. 2014 and enabled the morning of 9 Jul. 2014 to avoid insecticide venting after application. During these nine days, greenhouse ambient temperatures reached a high of 41.1°C during the day (Figure 2). The sharp increase in temperature and time length was replicated during year two to maintain experimental reproducibility. Dataloggers (Hobo U12, Onset, Bourne, MA) and compatible sensors were used to monitor air temperature conditions with a measurement recorded every 15 min, 24 h per day from 30 May–10 Sep. in both years. Photosynthetically active radiation (PAR) was recorded at the top of the plant canopy at noon on clear days from 11–28 Jun. A mean was calculated (AccuPAR PAR/LAI Ceptometer model LP-80; Decagon Devices, Inc., Pullman, WA).

In both years, plants were harvested twice to simulate early and late commercial harvests by hand, a common practice in New Mexico. The first harvest occurred at approximately 162 days after planting (DAP) and the second at around 192 DAP: 28 Jul. and 25 Aug. (year one) and 20 Jul. and 19 Aug. (year two). During each harvest, individual plants and their pods were photographed separately, and the plants were assigned a unique identifier number.

The horticulturally mature fruits (i.e., mature green pods) were harvested and counted. Next, the number of asymptomatic and symptomatic pods was noted. From those data, stip incidence was calculated by dividing the total number of pods with lesions by the total number of pods harvested and then multiplying by 100 to arrive at a percentage. Mean stip severity was calculated by dividing the number of lesions by the number of pods with lesions.

FIGURE 2. Recorded greenhouse temperature variation, including the nine days of elevated temperatures (1 July–9 July 2014). Note: Brackets frame the time of elevated temperatures, and an arrow designates when stip symptoms first became apparent. In order to maintain experimental reproducibility, this acute temperature change was repeated during year two.

FIGURE 3. A protocol modified from Bosland and Votava (2000) was developed for describing the node location of symptomatic stip pods and lesions. The first branch is identified as 1; secondary branches are identified as 2; tertiary branches off the secondary branch are identified as 3, and so on. Decimal points denote the intersection of two branches. Example: pod A was located at position 1.2 because it was found at the node between the primary stem and the secondary branches.

TABLE 1. Environmental greenhouse conditions (temperature and photosynthetically active radiation [PAR]) were recorded during the 2014 growing season (Feb.–Sep.). This table provides the range and average of measured values. The temperature was collected using a HOBO 4-Channel External Data Logger (Onset, Cape Cod, MA); PAR information was collected using an AccuPAR PAR/LAI Ceptometer model LP-80 (Decagon Devices, Inc., Pullman, WA).

	Min.	Max.	Average
Temperature (excluding temperature peak) (°C)	17.9	37	26.7
Temperature (during spike)	20	40	NA
PAR ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	599	1,396	1,116

TABLE 2. During the year one (2014) growing season, the average number of horticulturally mature fruits (i.e., mature green pods) produced by ‘AZ 1904’ (New Mexican pod type) and ‘Cal Wonder 300’ (bell pepper pod type) was calculated and the incidence and severity of stip symptoms were averaged.

Cultivar ^z	Total # of lesions	Total # of pods with lesions	Total # of pods harvested	Incidence ^y	Severity ^x
<i>Harvest 1 (166 DAP)</i>					
‘AZ 1904’	9.8	2.2	3.8	57%	4.6
‘Cal Wonder 300’	13.3	2.5	4.1	62%	5.2
<i>Harvest 2 (194 DAP)</i>					
‘AZ 1904’	6	1.4	5.2	26%	4.3
‘Cal Wonder 300’	0.8	0.4	4.4	8%	2.3

^z ‘AZ 1904’ $n=13$; ‘Cal Wonder 300’ $n=11$; Completely randomized design.

^y Number of pods with lesions divided by the total number of pods and multiplied by 100.

^x Number of lesions divided by the number of pods with lesions.

TABLE 3. During the year one (2014) growing season, a statistical analysis was performed to detect differences in the average number of horticulturally mature fruits (i.e., mature green pods) produced by ‘AZ 1904’ (New Mexican pod type) and ‘Cal Wonder 300’ (bell pepper pod type), including the incidence and severity of stip symptoms. A significant harvest by cultivar interaction was observed for stip incidence.

Variable	Harvest* cultivar interaction	Harvest	Cultivar
Pods harvested	ns	ns	ns
Incidence	*** ($p=0.0004$)	ns	* ($p=0.035$)
Severity (first harvest)	ns	ns	ns

^z *** indicates “very significant” ($p<0.01$).

^y * indicates “significant” ($0.01<p<0.05$).

^x ns indicates “not significant” ($p\geq 0.05$).

TABLE 4. During the year two (2015) growing season, the average number of horticulturally mature fruits (i.e., mature green pods) produced by ‘AZ 1904’ (New Mexican pod type) and ‘Cal Wonder 300’ (bell pepper pod type) was calculated, and the incidence and severity of stip symptoms were averaged.

Cultivar ^z	Total # of lesions	Total # of pods with lesions	Total # of pods harvested	Incidence ^y	Severity ^x
<i>Harvest 1 (158 DAP)</i>					
‘AZ 1904’	1.38	0.75	7.94	9%	1.8
‘Cal Wonder 300’	0.27	0.13	4.2	3%	2
<i>Harvest 2 (189 DAP)</i>					
‘AZ 1904’	5.1	2.7	9.8	27%	1.9
‘Cal Wonder 300’	0	0	4.27	0	0

^z‘AZ 1904’ $n=16$; ‘Cal Wonder 300’ $n=15$; Completely randomized design.

^yNumber of pods with lesions divided by the total number of pods and multiplied by 100.

^xNumber of lesions divided by the number of pods with lesions.

TABLE 5. During the year two (2015) growing season, a statistical analysis was performed to detect differences in the average number of horticulturally mature fruits (i.e., mature green pods) produced by ‘AZ 1904’ (New Mexican pod type) and ‘Cal Wonder 300’ (bell pepper pod type), including the incidence and severity of stip symptoms. A significant harvest by cultivar interaction was observed for stip incidence.

Variable	Harvest* cultivar interaction	Harvest	Cultivar
Pods harvested	ns	ns	ns
Incidence	*	ns	***
	($p=0.02$)		($p=0.00003$)
Severity (first harvest)	ns	ns	ns

^z *** indicates “very significant” ($p<0.01$).

^y * indicates “significant” ($0.01<p<0.05$).

^x ns indicates “not significant” ($p\geq 0.05$).

The location of symptomatic pods was identified using a protocol modified from Bosland and Votava (2000; Figure 3). This protocol involved quantifying each pod’s location relative to position one, the first significant branching intersection above the soil line. Counting continued upward to position two (the next node), where the secondary branches diverged into tertiary branches. This labeling process continued until all nodes were numbered. The specific node location of mature symptomatic and asymptomatic pods was recorded and visualized using heat maps.

Statistical analysis

A linear mixed model was conducted to determine the mean number of harvested pods, stip incidence, and stip severity between cultivars. The model tested the difference in the number of harvested pods across both years. Years and harvests nested in years were considered random factors, while cultivar was considered a fixed factor. This model was run as a repeated measure using each year’s harvests as the repeated measures since responses were autocorrelated across time. A variance was allowed to vary by year, by harvest, and by cultivar. A Gaussian distribution was used.

The model used to compare differences in mean incidence (number of pods with lesions ÷ number of harvested pods) combined across all years. Years and harvests nested in years were considered random factors, while cultivar was considered a fixed factor. Responses were autocorrelated across time. Binomial distribution was used.

Severity (number of lesions ÷ number of symptomatic pods) was tested only for the first year. Harvests were considered random factors, while cultivar was considered a fixed factor. This model was run as a repeated measure using the first year’s harvests as the repeated measures. Responses were autocorrelated across time, and variance across har-

vest was allowed to vary. Data were transformed using the log of the ratio of the number of lesions ÷ number of symptomatic pods. Again, a Gaussian distribution was used.

The collected data were analyzed using statistical software (R version 3.5.0, R Foundation for Statistical Computing, Vienna, Austria). Global f-test and pairwise comparisons using Fisher’s LSD were applied to the cultivar susceptibility evaluation data at a 5% significance level ($\alpha=0.05$). Upon analysis of year two data and the fact that a large number of zero values were recorded for the number of lesions and the total number of pods with lesions, we examined the first harvest data using Wilcoxon’s non-parametric test as recommended by Delucchi and Bostrom (2004).

Results and discussion

Environmental conditions

Environmental conditions (i.e., temperature and PAR) in the greenhouse were recorded throughout the growing season (Table 1). The temperature ranged from a low of 17.9°C to a high of 37°C, with an average temperature of 26.7°C. PAR was recorded between a low of 599 $\mu\text{mol m}^{-2} \text{s}^{-1}$ and a high of 1,396 $\mu\text{mol m}^{-2} \text{s}^{-1}$ with an average of 1,116 $\mu\text{mol m}^{-2} \text{s}^{-1}$. Symptom expression was not observed until air temperatures reached an elevated level of 41.1°C (Figure 2).

Year one (2014)

Beginning on 1 Jul., greenhouse temperatures rose to a maximum of 41.1°C (Figure 2). This period coincided with the emergence of symptomatic pods in both cultivars; circular lesions ranged between 5 mm to 15 mm in diameter. Lesions on symptomatic pods from ‘AZ 1904’ plants were typically more substantial and ovoid than lesions found on ‘Cal Wonder 300’ pods.

FIGURE 4. During the first harvest of year one (2014), the number of stip lesions at each node position was counted on two greenhouse-grown pepper cultivars, 'AZ 1904' and 'Cal Wonder 300.' This heat map shows the number of individual lesions tallied at each plant node position during the first harvest of the first year. The pattern or distribution of individual lesions is shown. Value = the number of lesions at that node.

FIGURE 5. During the second harvest of year one (2014), the number of stip lesions at each node position was counted on two greenhouse-grown pepper cultivars, 'AZ 1904' and 'Cal Wonder 300.' This heat map shows the number of individual lesions tallied at each plant node position during the second harvest of the first year. The pattern or distribution of individual lesions is shown. Value = the number of lesions at that node.

FIGURE 6. During the first harvest of year one (2014), the number of symptomatic pods at each node position was counted on two greenhouse-grown pepper cultivars, 'AZ 1904' and 'Cal Wonder 300.' This heat map shows the number of symptomatic pods tallied at each plant node position during the first harvest of the first year. The pattern or distribution of symptomatic pods is shown. Value = the number of lesions at that node.

FIGURE 7. During the second harvest of year one (2014), the number of symptomatic pods at each node position were counted on two greenhouse-grown pepper cultivars, 'AZ 1904' and 'Cal Wonder 300.' This heat map shows the number of symptomatic pods tallied at each plant node position during the second harvest of the first year. The pattern or distribution of symptomatic pods is shown. Value = the number of lesions at that node.

At the first harvest, the incidence for 'Cal Wonder 300' was 62%, while the average severity observed was 5.2 lesions per symptomatic fruit. According to the only literature study, which reported the incidence and severity levels for 'Cal Wonder 300' in the field, the incidence was lower at 30.6%, but the severity was higher with 7.2 lesions per symptomatic pod (Smith et al., 1998). Meanwhile, cultivar 'AZ 1904' was observed to have 57% incidence with 4.6 lesions per symptomatic fruit on average. When comparing the two cultivars in the greenhouse, there were no differences between the various tested variables during this first harvest (Tables 2 and 3).

Incidence and severity for both cultivars were reduced at the second harvest. Eight percent of all 'Cal Wonder 300' pods harvested were symptomatic (incidence) with an average of 2.3 lesions per symptomatic fruit; 26% of the harvested 'AZ 1904' were symptomatic with an average of 4.3 lesions per symptomatic fruit. Symptom incidence was found to be significantly different between the two tested cultivars during the second harvest.

Year two (2015)

In year two, we observed a lower incidence and severity of stip for both cultivars compared to year one. Since 'Cal Wonder 300' produced symptomatic pods during the first harvest but no symptomatic pods during the second harvest, the harvests were analyzed separately. There was a significant difference in symptom incidence during the first harvest of the second year: 'AZ 1904' showed low to moderate levels of susceptibility to stip while 'Cal Wonder 300' showed a moderate to a high degree of resistance (Tables 3 and 4).

Node location of symptomatic pods and lesions

Symptomatic pods generally appear each year on the lower canopy (i.e., node position <4) of field-cultivated plants at the beginning of the season in southern New Mexico and higher in the canopy (i.e., node position >4) due to indeterminant growth as the season progresses into the early fall, which is the natural progression of peppers usually grown in this region (B. Etcheverry, pers. commun.). This same trend was seen in the location of both lesions and symptomatic pods in our greenhouse cultivar susceptibility evaluation. It appeared that symptoms generally manifested where new growth was occurring. For example, during the first harvest for both years (year one, 166 DAP; year two, 158 DAP), symptomatic pods and lesions were generally found between nodes 1–4, and at higher node positions (5–9) at the second harvest (189–194 DAP year one; 189 DAP year two) (Figures 6–9).

An apparent difference between 'AZ 1904' and 'Cal Wonder 300' was that symptomatic pods in the latter tended to locate in a narrower distribution of node positions. For example, in year one at harvest one, symptomatic pods and lesions from 'Cal Wonder 300' could be found between nodes 1–4, whereas, symptomatic pods from 'AZ 1904' were found between nodes 1–6 (significant at 0.05) (Figures 4 and 6). This pattern persisted during the second harvest, and symptomatic pods and lesions on 'Cal Wonder 300' were only found at nodes 5–6 (Figures 5 and 7). In contrast, symptomatic pods and lesions on 'AZ 1904' were found across a more extensive node range (nodes 3–13). Similarly, during year two at harvest one, symptomatic pods on 'Cal Wonder 300' were found between nodes 3–4 in contrast to 'AZ 1904', which produced symptomatic pods between nodes 1–4. During the second harvest, 'Cal Wonder 300' did not show stip expression, but symptomatic pods from 'AZ 1904' were observed at nodes 3–9.

Conclusion

The development of stip symptoms in two commercially grown pepper cultivars was observed during two consecutive years' harvests in a greenhouse. Stip symptoms seemed to be in response to elevated temperatures since that was when symptoms became apparent. Symptom expression was possibly a result of physiological stress that resulted from either the increased temperature variation or the maximum temperature achieved. Also, the localization pattern – distribution of symptomatic pods and lesions – was consistent in both cultivars and occurred at nodes with the most recent growth. For example, during the first year's harvest, both symptomatic pods and lesions were predominantly observed between nodes 1–4 and between nodes 5–9 during the second year's harvest. This pattern has similarly been reported in New Mexican pod-type peppers grown in southern New Mexico. It was also apparent that cultivars 'Cal Wonder 300' and 'AZ 1904' differed significantly in degree of susceptibility. During both years, the bell-type pepper 'Cal Wonder 300' showed moderate to strong resistance, while New Mexican-type pepper 'AZ 1904' demonstrated moderate susceptibility. Future studies could be done to determine whether this particular bell pepper is typically more resistant to stip than the New Mexican pepper or if this difference is more cultivar specific. Lastly, this work demonstrated a new methodology for labeling the location of symptomatic pods and lesions and could help in future breeding and selection for stip resistance.

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Addresses of authors:

J.C. Fulton¹, R. Steiner², J.C. Colee³ and M.E. Uchanski^{4,*}

¹ Plant Pathology, University of Florida, 2550 Hull Road, P.O. Box 110680, Gainesville FL 32611-0680, U.S.A.

² Economics, Applied Statistics, & International Business Department, New Mexico State University, MSC 3CQ, P.O. Box 30001, Las Cruces, NM 88003-0095, U.S.A.

³ Statistical Consulting Unit, Institute of Food and Agricultural Sciences, University of Florida, P.O. Box 117169, Gainesville, FL 32611-7169, U.S.A.

⁴ Horticulture and Landscape Architecture, Colorado State University, 1173 Campus Delivery, Fort Collins, CO 80523-1173, U.S.A.

* Corresponding author;

E-mail: mark.uchanski@colostate.edu