# DEVELOPMENT OF A PREDICTIVE DEGREE-DAY MODEL FOR AIRBORNE ERGOT ASCOSPORES IN PERENNIAL RYEGRASS SEED PRODUCTION SYSTEMS OF EASTERN OREGON

*J.K.S. Dung, S.C. Alderman, N. Kaur, D.L. Walenta, K.E. Frost, and P.B. Hamm*

**Introduction**

Ergot is a major disease of perennial ryegrass seed crops in the Columbia Basin of Oregon and other irrigated production regions of the Pacific Northwest. Ergot reduces yield, hinders seed certification efforts, and can be particularly difficult to manage. The fungus that causes ergot, *Claviceps purpurea*, infects the unfertilized flowers of grasses and grains and transforms seed into dormant resting structures (sclerotia) of the fungus, which overwinter and produce primary inoculum (ascospores) the following season.

Since ergot infects only unfertilized flowers, ascospore production by the fungus must coincide with the flowering of susceptible grass hosts for infection to occur. In some years, the timing of spore release and host anthesis does not coincide, resulting in little to no ergot. It is suspected that environmental conditions can contribute to this lack of synchrony between host anthesis and pathogen spore production. We hypothesize that an ergot phenology model can be used to inform growers if or when fungicides may be necessary and improve the timing of fungicide application to enhance ergot control. The objective of this study was to develop and validate a predictive model for ergot spore production in perennial ryegrass seed production systems of eastern Oregon.

**Materials and Methods**

Burkard 7-day volumetric spore traps (Burkard Scientific Ltd., Uxbridge, Middlesex, UK) were used to trap airborne ascospores of *C. purpurea* in three commercial perennial ryegrass fields and two artificially infested perennial ryegrass plots between 2013 and 2015. All fields and plots were located in Umatilla County, OR, subjected to similar cultural practices, and irrigated using center pivot irrigation as is typical in the region.

A spore trap was placed in field BASIN-A (cv. 'Pavilion') between April 3 and June 19, 2013 and from April 22 to June 27, 2014. In 2013, spores were sampled from field BASIN-B (cv. 'Top Hat II') between April 3 and June 15. Field BASIN-C (cv. 'Pavilion') was sampled from April 2 to June 22, 2015. Spore traps were placed in artificially infested plots at the Hermiston Agricultural Research and Extension Center (HAREC) between April 11 and June 23 in 2014 and from April 4 to June 22 in 2015. Spore traps were situated in the grass seed crops approximately 500 feet from the field borders, and the air intake orifices were approximately 1.5 feet above ground level. Spore trap tapes were collected weekly, processed, and analyzed as described by Alderman (1993). The number of ascospores trapped per hour was counted under a microscope at 300X magnification to determine ascospore counts for each 24-hour period (12:00 a.m. to 11:59 p.m.).

Daily minimum and maximum air temperature data were compiled from the HRMO weather station in the AgriMet Northwest Cooperative Agricultural Weather Network, which is located at the HAREC. Degree-days were calculated beginning on January 1 of each year. A base temperature of 50°F and an upper threshold temperature of 77°F were used for degree-day calculations based on previous studies (Uppala et al., 2012) and weather data collected in this study.

The degree-day model was validated using spore trap data that were not used for model development. The spore trap data used for model validation were collected as described above in five different 125-acre commercial perennial ryegrass seed fields (2008, 2009, 2010, 2012, and 2016) and two artificially infested 1-acre perennial ryegrass seed plots located at HAREC (2010 and 2016). All five commercial fields were planted and managed by the same grower as the other commercial fields used in this study.

**Results and Discussion**

Overall, a degree-day period between 414 and 727 accounted for the occurrence of 93% of the total ascospores trapped between 2008 and 2016 (Table 1). Among the individual years, the degree-day period accounted for 96%, 76%, and 94% of the total ascospores trapped in 2013, 2014, and 2015, respectively. When validated against historical data, the degree-day model accounted for 82% of ascospores trapped in 2008, 84% of ascospores trapped in 2009, 90% of the total ascospores trapped in 2010, and 87% of total ascospores trapped in 2012. The degree-day model was tested using spore trap data in 2016 and accounted for 85% of the total ascospores trapped

Table 1. Number of *Claviceps purpurea* ascospores trapped when accumulated degree-days were between 414 and 727 compared to the total number of ascospores trapped during the cool-season grass seed production season at 11 study sites, Umatilla County, OR, 2008–2016.[1]

| | | | | | ---------- Ascospores trapped ---------- | | |
|---|---|---|---|---|---|---|---|
| Year | Start date | End date | Days | Field | Degree-days 414 to 727 | Entire season | % total |
| 2008 | May 25 | June 17 | 23 | BASIN-08 | 6,472 | 7,855 | 82 |
| 2009 | May 24 | June 9 | 16 | BASIN-09 | 12,335 | 14,673 | 84 |
| 2010 | May 18 | June 17 | 30 | BASIN-10 | 1,650 | 2,270 | 73 |
| | | | | HAREC-10 | 14,046 | 15,196 | 92 |
| 2012 | May 19 | June 14 | 26 | BASIN-A | 5,307 | 6,124 | 87 |
| 2013 | May 11 | June 7 | 27 | BASIN-A | 54,114 | 56,144 | 96 |
| | | | | BASIN-B | 109,726 | 114,525 | 96 |
| 2014 | May 12 | June 2 | 21 | BASIN-A | 12,402 | 16,236 | 76 |
| | | | | HAREC-14 | 1,580 | 2,260 | 70 |
| 2015 | May 4 | May 26 | 22 | BASIN-C | 37,070 | 38,917 | 95 |
| | | | | HAREC-15 | 666 | 1,083 | 61 |
| 2016 | May 1 | May 24 | 23 | BASIN-16 | 1,538 | 1,820 | 85 |
| | | | | HAREC-16 | 192 | 208 | 92 |
| Average | May 14 | June 6 | 23.5 | — | 257,098 | 277,311 | 93 |

[1]Air degree-days were calculated using lower and upper thresholds of 50 and 77°F, respectively. Degree-day accumulations began on January 1.

in 2016, indicating that this degree-day model is a useful predictor for ascospore production periods. Additionally, the degree-day model was tested using spore trap data collected from Kentucky bluegrass fields in central Oregon and accounted for 91 and 84% of ascospores trapped in 2015 and 2016, suggesting that this model may be useful for other irrigated grass seed production regions.

The degree-day period identified in this study started as early as May 1 (in 2016) or as late as May 25 (in 2008) and ended as early as May 24 (in 2016) or as late as June 17 (in 2008 and 2010). The length of this degree-day period ranged between 16 and 30 days, averaging 23.5 days between 2008 and 2016.

Fungicides labeled for ergot in grass seed crops have application intervals ranging from 10 to 21 days, suggesting that growers could use this model for informed timing of two or three fungicide sprays during anthesis, thus protecting their crops against the majority of ascospores produced during the season. However, it is important to note that a small proportion of ascospores can be present before the beginning of the degree-day period identified in this study, so growers may need to make their first fungicide application prior to the degree-day period to ensure flowers are protected before inoculum production begins.

To our knowledge, this is the first predictive degree-day model developed for *C. purpurea* ascospore production. The ability to predict when *C. purpurea* ascospores are most likely to be present will help inform growers if or when fungicide applications would be required during anthesis of grass seed crops. It is anticipated that this model will become an important component of an integrated disease management strategy that incorporates cultural practices, host resistance and/or disease escape, field scouting (Dung et al., 2013), spore trapping (Dung et al., 2016), chemical control (Dung et al., 2013), and grower outreach (Walenta et al., 2016) to improve ergot management in perennial ryegrass seed crops.

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