EFFECTS OF HIGH TEMPERATURES ON CERCOSPORA LEAF SPOT INFECTION AND SPORULATION AND EFFECTS OF VARIETY AND NUMBER OF FUNGICIDE SPRAYS ON YIELD

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Cercospora leaf spot **(CLS)** caused by the fungus *Cercospora beticola* is considered an important disease on more than 66% of U.S. sugarbeet acreage and all acreage in ND, MN and MT. (Jacobsen, et. al., 2001). Losses without controls in eastern MT and western ND have averaged 2-3 tons per acre and 0.5-1.5 % lower sugar yield in the past decade ($100-350 or more /A) (Jacobsen, et.al, 1997b, 1998c, 1999a, 2000a, 2003). In addition to direct field losses, roots from CLS damaged plants are more subject to decay in storage piles and sugar extraction efficiency is much reduced due to higher levels of impurities (Whitney and Duffus, 1986; Windels, et.al., 1998). Management strategies for CLS include use of crop rotations of 3 or more years, clean tillage in the fall, separation of current year fields from previous years fields by 100 yards or more, moderately resistant varieties, weather based disease prediction models, and fungicide application. (Windels et.al., 1998). Growers typically spent $40-$90/ A for fungicide application each year.

Historically, varieties with more than moderate levels of resistance have had poor reception due to the demonstrated correlation between resistance and low yield potential (Smith and Campbell, 1996 and Jacobsen et. al, 1996). During the past 4 years, however, Jacobsen et.al, (2000a; 2001, 2002, 2003) showed that varieties with moderate levels of resistance to CLS do not have reduced yield potential and could be as profitable as susceptible varieties when sprayed with 1-2 fewer fungicide applications. However, disease pressure has been only moderate (2000, 2001, 2002) to light (2003) during the course of these studies. It is hoped that these same results will be achieved under moderate to severe epidemics.

Growers in ND, MN and MT have historically relied on the disease prediction and loss model developed by Shane and Teng, 1985, scouting and fungicide applications (Windels et.al, 1998). The Shane and Teng (1985) model relies on weather data including number of hours with relative humidity greater than 95% and the average temperature during these hours of high relative humidity. In practice it has been modified using 85-87% relative humidity instead of 95% as a surrogate for leaf wetness. The model was based on growth chamber experiments conducted at 18, 20, 23, 25 and 28°C (64, 68, 73, 77 and 82°F) supplemented with data from Wallin and Loon (1971) where temperatures of 29, 32 and 35°C (84, 89, and 95°F) were tested. While this model has resulted in better control, fungicide use in ND, MN and MT continues to be a key element in CLS management because both growers and sugar factories have seen increased profitability where CLS is controlled.

In 2003, the Shane and Teng model predicted moderate to severe CLS potential starting in early-July at the Eastern Agricultural Research Center (the Sidney factory district), but the CLS epidemic did not reach the economic threshold (3% leafspot) over the entire growing season on susceptible varieties, even though there was significant initial; infection on July 1. We hypothesize that two factors contributed to the poor performance of the model in 2003. First, In 2003 during the critical time July 1 to August 15, there were 18 days with 4 or more hours between 90 and100°F with 4 of those days with at least 3 hours over 100°F (up to 106°F). In development of the model, 95°F was the highest temperature tested. These extremely high temperatures in 2003 may have negatively impacted Cercospora infection and growth in the plant and it is critically important to determine the effects of these higher temperatures on Cercsopora sporulation and infection parameters especially in light of “global warming”. In 2004 we examined the effect of temperature on Cercospora leaf spot infection, latent period and the production of spores per lesion.

METHODS

Experiments were performed in controlled environment growth chambers and will include determination of latent period for development of CLS in varieties with a range of KWS scores (6.2-4.6). Sugarbeet varieties Holly Hybrid 88 and 115, Beta 3820, Monarch, Van der Have 66556 and ACH 927 were used in this study. *Cercospora beticola* inoculum was grown on PDA for 2 weeks and sporulation will be induced by a 1 week exposure to UV light. Spores will be harvested by flooding the agar surface with water and scraping with a clean microscope slide. Conidia were counted with a haemocytometer and the spore concentration will be adjusted to 10^4 conidia/ml. The spore suspension will be sprayed onto the leaves of plants at the 8 leaf growth stage until run-off and plants were placed in growth rooms maintained at 25, 29, and 40 ^{0}C, kept in tents @100% humidity for 48 hours and evaluated daily for development of sporulating leaf spots. The time from initial inoculation to sporulation (latent period) were recorded and after 21 days, disease severity ratings were made using the KWS rating scale. Sporulation was determined by placing leaf spots in moist chambers for 24 hours at room temperature, placing a droplet of water on the lesion with a micropipette and then extracting the droplet and spores. Spores were counted with a haemocytometer.

Field studies were conducted at the Eastern Agricultural Research Center at Sidney, MT. Plots were planted April 26, 2004 in 22" rows. A randomized complete block design with six replicates was used. Standard agronomic practices were used. Sprays were initiated on July 27 and a 14 day spray interval was used. Apllications were made with a CO_2 sprayer @ 16 gallons/A. Harvest was done on September 28 and 29, 2004.

RESULTS

Results of growth chamber studies are presented in Table 1. These data clearly show the effect of temperature on latent period (time from infection to first spore production) and disease severity, with the latent period for all varieties being 33% longer at 104 ^{0}F than at lower temperatures. The effect of longer latent period is to slow the rate of the epidemic. Disease severity as measured by the percent of leaf area covered by lesions was dramatically reduced for all temperatures > 77 ^{0}F. This data is particularly important when one considers that 3% disease severity is considered the level at which economic damage occurs. The effect of resistance was most pronounced at 83^0 F and was not a factor at the other temperatures. While the data are not complete it appears that for the two varieties for which data analysis is complete that spore production per lesion is reduced nearly 10 fold at 104 ^{0}F.

This data clearly shows why this type of research needs to be done to develop models for grower use that take into account a full range of temperatures and the effect of variety resistance. Data for the 86, 95 and 98 ^{0} F temperatures and remaining data for sporulation per lesion are being developed at this time and will be included in a final report. The data for these temperatures was delayed by access to growth chambers that will support high humidity's and these temperatures.

Table 1. Effect of temperature on Cercospora leaf spot infection, latent period and sporulation

Variety-KWS	77 ^{0}F			83 ^{0}F			104 ^{0}F		
	Latent period days	% disease severity	Spore per lesion	Latent period	% disease severity	Spores per lesion	Latent period	% disease severity	Spores per lesion
HH 88-6.2	10	17.2	2.4×10^5	10	10.2	3.0×10^5	13	0.15	6.0×10^4
Trophy-5.3	10	11.4	*	10	4.8	*	13	0.25	*
AC 927-4.2	10	15.9	*	10	7.2	*	13	0.08	*
Beta 3820-4.2	10	18.5	*	10	6.0	*	13	0.15	*
VDH 66556-4.6	10	27.5	*	10	7.2	*	13	0.28	*
Holly 115-4.4	10	17.2	3.0×10^5	10	6.6	3.1×10^5	13	0.63	5.0×10^4
Sx Monarch-4.6	10	13.3	*	10	6.6	*	13	0.13	*
FLSD p=0.05		ns			0.1			0.1	

- data being determined at time of this writing as are data for 86, 95 and 98^{0}F

Result of field studies are shown in Table 2. No significant disease developed due to the near absence of any night temperatures > 60 ^{0}F during the growing season. There were no significant differences between varieties or spray programs.

Table 2. 2004 Sidney Variety-Fungicide Summary

Variety	Tons/A	Percent Sucrose	Extractable Sucrose
Monarch	**30.3**	**18.9**	**11,417**
HH 115	**30.9**	**19.5**	**13,356**
VDH 66556	**30.2**	**19.3**	**11,692**
Beta 3820	**29.8**	**19.5**	**11,582**
AC 927	**29.6**	**19.8**	**11,659**
FLSD p=0.05	**ns**	**ns**	**ns**
Treatment			
1. **Untreated**	**29.8**	**19.9**	**11,874**
2. **Headline** 9.0 oz/A-(**1 spray)**	**30.4**	**19.0**	**11,475**
3. **Headline** 9.0 oz/A then **Eminent** 13 oz/A **(2 spray)**	**30.0**	**19.5**	**11,679**
4. **Headline** 9.0 oz/A then **Eminent** 13 oz/A then **SuperTin** 5 oz/A **(3 spray)**	**30.2**	**19.3**	**13,315**
6. **Eminent 6.5 oz + Bac J**, then 2 **Bac J (3 total sprays)**	**30.4**	**19.3**	**11,746**
7. **Eminent 6.5 oz** then 2 **Bac J (Total 3 sprays)**	**29.9**	**19.1**	**11,430**
8. 3 **applications of Bac J**	**30.7**	**19.0**	**11,629**
FLSD P=0.05	**NS**	**NS**	**NS**

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