Full

ANTHRACNOSE DISEASE RATINGS FOR ALFALFA VARIETIES AND EXPERIMENTAL STRAINS

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Anthracnose Disease Ratings for Alfalfa Varieties and Experimental Strains

by
T.E. Devine, T.A. Campbell, and C.H. Hanson[1]

Anthracnose disease of alfalfa is known to result in severe losses to forage production and marked decrease in stand longevity in the Southeastern United States. The extent of damage in the southern Corn Belt States is now being determined. The disease, caused by the fungus *Colletotrichum trifolii* Bain, was first reported by Bain and Essary in 1906 (*1*).[2] Since then, however, little attention has been given to the development of resistance to this disease.

Anthracnose develops during the warm humid period of the growing season (*4*). The fungus penetrates the stems of susceptible plants and forms black oval-shaped lesions. From the stem, the fungus spreads through the crown causing a black discoloration (*9*). Diseased crowns produce less vigorous growth and permit weeds to encroach upon the sward (*8*). If environmental conditions are conducive to the development of a severe epiphytotic, susceptible plants are killed and the stand is lost prematurely (*2*).

This report presents the results of a survey of alfalfa varieties and experimental strains for susceptibility to anthracnose under controlled inoculation.

Testing Procedures

Seeds of alfalfa varieties and advanced experimental strains with potential for use as varieties were requested from public and private alfalfa breeders in the United States. The sources of seed are listed in table 1. The code number assigned each source in table 1 identifies the same source in table 2.

Seeds were planted on steamed soil covered with fine sand in sterilized wooden flats. Plots consisted of two adjacent rows of 15 seeds each. The seeds were covered with sterilized 4-Q-ROK sand. The seedlings were grown in a controlled environment chamber at 23° C with a light intensity of 17.2 klux for 16 hours each day. Fourteen days after seeding the flats were placed in a mist chamber. When the foliage was uniformly covered with water droplets, anthracnose inoculum was dusted on the flats at the rate of 10 g per flat. The inoculum was prepared by grinding dried stems and leaves of dead or severely infected plants previously inoculated with anthracnose (*3*). The test seedlings were held in the moisture-saturated atmosphere for 72 hours.

Eleven days after inoculation the seedlings were scored for anthracnose reaction on a scale of 1 to 5 (*11*), as follows:

- Type 1 —highly resistant; absence of lesions; considered virtually immune.
- Type 2 —long, narrow lesions.
- Type 3 —lesions wide, but do not girdle the stem.
- Type 4 —distinguished by long, coalescing lesions that girdle and kill the stem.
- Type 5 —lethal to the entire seedling.

[1]Research geneticist, agronomist (research assistant), and research agronomist, formerly Applied Plant Genetics Laboratory; now with Plant Nutrition Laboratory, Pesticide Action Laboratory, and National Program Staff, respectively, Agricultural Research Center, Beltsville, Md. 20705

[2]Italic numbers in parentheses refer to Literature Cited, p 7.

Table 1.—Sources of seed for alfalfa varieties and strains characterized for resistance to anthracnose

Code number[1]	Sources of seed
1	J. D. Axtell, Purdue University, Lafayette, Ind. 47907
2	D. K. Barnes, ARS, USDA, University of Minnesota, St. Paul, Minn. 55101
3	Barzen of Minneapolis, Inc., Minneapolis, Minn. 55413
4	D. F. Beard, Waterman-Loomis Co., Adelphi, Md. 20783
5	E. H. Beyer, Farm Seed Research Corporation, San Juan Bautista, Calif. 95045
6	K. E. Bohnenblust, University of Wyoming, Laramie, Wyo. 82070
7	R. J. Buker, Farmers Forage Research Cooperative, W. Lafayette, Ind. 47906
8	T. H. Busbice, ARS, USDA, North Carolina State University, Raleigh, N.C. 27607
9	G. R. Buss, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061
10	A. E. Carleton, Montana State University, Bozeman, Mont. 59715
11	J. H. Elgin, Jr., ARS, USDA, Prosser, Wash. 99350
12	E. S. Horner, University of Florida, Gainesville, Fla. 32601
13	O. J. Hunt, ARS, USDA, University of Nevada, Reno, Nev. 89507
14	I. J. Johnson, Cal/West Seeds, Woodland, Calif. 95695
15	H. E. Kaerwer, Northrup, King & Co., Minneapolis, Minn. 55413
16	W. R. Kehr, ARS, USDA, University of Nebraska, Lincoln, Nebr. 68503
17	W. F. Lehman, University of California, Imperial Valley Field Station, El Centro, Calif. 92243
18	B. A. Melton, New Mexico State University, Las Cruces, N. Mex. 88001
19	J. W. Miller, Arnold-Thomas Seed Service, Johnston, Iowa 50131
20	M. K. Miller, Arnold-Thomas Seed Service, Fresno, Calif. 93723
21	J. L. Mings, Northrup, King & Co., Washington, Iowa 52353
22	R. P. Murphy, Cornell University, Ithaca, N.Y. 14850
23	M. S. Offutt, University of Arkansas, Fayetteville, Ark. 72701
24	R. N. Peaden, ARS, USDA, University of Nevada, Reno, Nev. 89507
25	M. W. Pederson, ARS, USDA, Utah State University, Logan, Utah 84322
26	M. D. Rumbaugh, South Dakota State University, Brookings, S. Dak. 57006
27	W. B. Rusconi, Security Seed Co., San Joaquin, Calif. 93660
28	M. H. Schonhorst, University of Arizona, Tucson, Ariz. 85721
29	E. L. Sorensen, ARS, USDA, Kansas State University, Manhattan, Kans. 66502
30	E. H. Stanford, University of California, Davis, Calif. 95616
31	P.L.F. Sun, L. Teweles Seed Co., Clinton, Wis. 53525
32	J. R. Thomas, Rudy-Patrick Co., Ames, Iowa 50012
33	J. W. Vaccaro, Northrup, King & Co., Woodland, Calif. 95695
34	In storage, Applied Plant Genetics Laboratory, ARS, USDA, ARC, Beltsville, Md. 20705

[1]For use in table 2.

One hundred and thirty-four varieties and experimental strains were tested and compared with 10 check varieties or experimental strains. Six of these checks were highly resistant strains developed for resistance to anthracnose by laboratory selection at Beltsville, Md. (Beltsville 1-An4, Beltsville 2-An4, Beltsville 3-An4, MSA-CW3An3, MSB-CW5An3, and 'Arc', which was tested under the experimental designation MSHp6F-An4W4). They were described by Devine and others (*6*) and Hanson and others (*10*). 'Saranac', 'Williamsburg', and 'Cherokee' were the susceptible checks. 'Team' was characterized as having a low level of resistance. The experimental design was a randomized complete block with five replications.

Anthracnose Ratings

Frequency distributions for disease score classes and mean scores for each variety and strain are presented in table 2. All of the entries tested were susceptible to anthracnose except eight which were bred for resistance at Beltsville, Md. Six of the strains developed at Beltsville (Beltsville 1-An4, Beltsville 2-An4, Beltsville 3-An4, MSA-CW3An3, MSB-CW5An3, and Arc) were highly resistant to

Table 2.—Anthracnose resistance of alfalfa varieties and experimental strains, expressed as frequency distributions of plants in score classes and mean score

Variety or experimental strain	Source of seed[1] (code No.)	Percentage of plants in score classes[2]					Mean score	Number of plants tested
		1	2	3	4	5		
Alfa	32	0.0	2.9	4.3	73.9	18.8	4.10	69
Anchor	32	8.3	6.4	11.0	74.3	0.0	3.52	109
Apalachee	8	9.6	16.4	9.6	61.6	2.7	3.30	73
Apex	32	2.3	0.0	11.6	65.1	20.9	4.02	43
Arnim (D121)	20	10.2	0.0	1.7	78.0	10.2	3.79	59
AS-11	5	10.2	4.6	16.7	65.7	2.8	3.47	108
AS-13	5	8.7	2.9	10.7	76.7	1.0	3.58	103
AS-49	5	10.2	4.1	7.1	76.5	2.0	3.56	98
AS-63	5	5.5	0.0	9.6	82.2	2.7	3.77	73
ATCAL 8	20	5.6	0.0	7.8	82.2	4.4	3.78	90
Atlantic	34	10.8	0.0	8.6	72.0	8.6	3.68	93
ATRA 55	19	0.0	3.0	3.0	89.1	5.0	3.96	101
A-24	5	4.0	1.3	6.7	78.7	9.3	3.89	75
A-59	5	6.1	10.2	10.2	61.2	12.2	3.68	49
BIC, Cycle 5[3]	2	8.9	4.5	9.8	76.8	0.0	3.52	112
BH-22	5	3.3	6.6	6.6	73.8	9.8	3.80	61
Bonus	14	6.7	4.0	12.0	73.3	4.0	3.66	75
Buffalo	29	4.8	0.0	7.1	78.6	9.5	3.89	42
Caliente	5	0.9	0.9	5.4	80.2	12.6	4.02	111
Calif. Common 49	30	15.1	5.8	17.4	60.5	1.7	3.27	86
Caliverde	30	11.6	7.2	11.6	68.1	1.4	3.40	69
Caliverde 65	30	8.0	15.9	13.6	59.1	3.4	3.34	88
Cardinal	21	4.0	1.6	8.1	84.7	1.6	3.72	124
Cayuga	34	3.5	0.0	2.3	88.4	5.8	3.93	86
Cody	29	7.5	4.5	14.9	64.2	9.0	3.62	67
Culver	1	8.1	1.6	6.5	79.0	4.8	3.77	62
Dawson	34	4.2	2.8	2.8	85.9	4.2	3.83	71
Dawson-DCC67	16	9.4	2.4	4.7	77.6	5.9	3.67	85
Delta	34	16.1	1.6	3.2	72.6	6.5	3.54	62
DF-44	5	6.0	3.0	4.5	73.1	13.4	3.84	67
Dominor	21	1.8	8.9	3.6	75.0	10.7	3.89	56
DuPuits	21	2.7	2.7	13.5	70.3	10.8	3.86	37
Dura Stan	31	1.3	1.3	9.1	83.1	5.2	3.90	77
FFR DC6	7	15.2	1.3	7.6	69.6	6.3	3.62	79
FFR 2X4	7	23.7	5.3	0.0	68.4	2.6	3.21	38
Florida 66	12	8.6	4.9	24.7	61.7	0.0	3.40	81
Fremont	6	6.4	5.5	5.5	77.1	5.5	3.69	109
Gemini	15	25.0	10.7	11.6	50.0	2.7	2.92	112
Glacier	21	8.0	2.3	2.3	81.8	5.7	3.72	88
Grimm	34	9.1	4.5	6.8	70.4	9.1	3.66	44
Haymor	15	10.1	0.0	6.7	78.7	4.5	3.70	89
Indian	34	9.4	0.9	10.4	76.4	2.8	3.62	106
Iroquois	22	7.2	1.2	6.0	74.7	10.8	3.85	83
Joaquin 11	27	8.7	4.3	17.4	60.9	8.7	3.57	46

See footnotes at end of table.

Table 2.—Anthracnose resistance of alfalfa varieties and experimental strains, expressed as frequency distributions of plants in score classes and mean score—Continued

Variety or experimental strain	Source of seed[1] (code No.)	Percentage of plants in score classes[3]					Mean score	Number of plants tested
		1	2	3	4	5		
Kanza	29	4.0	2.0	4.0	86.0	4.0	3.80	50
Kayseri	34	7.2	0.8	2.4	79.2	10.4	3.86	125
KBP	20	3.9	0.9	7.8	78.4	8.8	3.87	102
KN-33	5	7.1	2.9	8.6	65.7	15.7	3.84	70
KO-8	21	0.0	0.0	11.6	88.4	0.0	3.88	43
Ladak	34	7.9	3.4	0.0	60.7	28.1	3.98	89
Ladak 65	10	8.2	2.0	5.1	71.4	13.3	3.81	98
Lahontan	24	4.9	3.3	13.1	63.9	14.8	3.82	61
Luna (D/FS55 6052)	20	30.8	6.2	10.8	52.3	0.0	2.85	65
Mesa-Sirsa	28	6.1	11.0	19.5	62.2	1.2	3.44	82
Mesilla	18	3.1	1.0	3.1	77.6	15.3	4.06	98
Minn. Syn M	2	4.2	1.7	2.5	74.8	16.8	4.00	119
Minn. Syn N	2	5.5	2.7	4.1	75.3	12.3	3.87	73
MnP-A2	2	9.0	14.4	15.3	56.8	4.5	3.33	111
MnP-B1	2	2.7	6.3	11.7	74.8	4.5	3.72	111
MnP-C2	2	4.0	0.0	1.0	81.2	13.9	4.01	101
MnP-D1	2	1.2	1.2	6.2	81.5	9.9	3.98	81
Moapa	24	17.0	4.5	23.9	53.4	1.1	3.16	88
Moapa 69	24	8.3	7.3	20.2	59.6	4.6	3.46	109
MX-45	31	2.5	1.3	7.6	79.7	8.9	3.92	79
MX-82	31	3.4	2.2	3.4	80.9	10.1	3.92	89
New Mexico 11-1	18	11.7	6.5	9.1	71.4	1.3	3.47	77
N.Y. 70-18A[4]	22	4.2	0.0	2.1	83.3	10.4	3.93	48
N.Y. 71-22[5]	22	8.5	0.0	2.1	75.5	13.8	3.85	94
N.Y. 71-23[6]	22	0.0	2.5	4.9	76.5	16.0	4.06	81
Norseman	3	5.8	0.0	0.0	75.6	18.6	4.01	86
N6-614	33	3.8	1.2	2.5	82.5	10.0	3.94	80
N 71 (C518)	20	0.0	4.3	10.6	83.0	2.1	3.83	47
N 78 (9-503RT1R)	20	1.9	0.9	7.4	78.7	11.1	3.96	108
PAT 30	19	3.6	6.0	3.6	63.9	22.9	3.96	83
Progress	34	6.5	6.5	9.1	71.4	6.5	3.60	77
Promor	21	5.2	3.4	12.1	69.0	10.3	3.76	58
Ranger	34	1.6	3.2	1.6	72.6	21.0	4.09	62
Resistador	21	0.0	2.7	2.7	75.7	18.9	4.09	37
Scout	7	2.7	2.7	11.0	80.8	2.7	3.79	73
Socheville	31	2.9	3.9	2.9	82.4	7.8	3.88	102
Sonora	34	11.5	7.7	21.8	59.0	0.0	3.28	78
Stride	14	11.5	3.8	5.8	63.5	15.4	3.64	52
Superstan	31	2.1	9.5	5.3	71.6	11.6	3.81	95
SW Comp. -An3[7]	13	50.9	20.2	15.8	13.2	0.0	1.91	114
SW32-An3[7]	13	46.7	21.0	20.0	11.4	1.0	1.99	105
SW-44	30	5.3	2.6	10.5	71.1	10.5	3.80	76
Syn 70-2	14	3.5	1.7	0.9	93.9	0.0	3.86	115
Syn 70-5	14	5.6	0.9	8.4	81.3	3.7	3.77	107

See footnotes at end of table.

Table 2.—Anthracnose resistance of alfalfa varieties and experimental strains, expressed as frequency distribution of plants in score classes and mean score—Continued

Variety or experimental strain	Source of seed[1] (code No.)	Percentage of plants in score classes[3]					Mean score	Number of plants tested
		1	2	3	4	5		
Syn 70-6	14	7.4	0.0	6.2	85.2	1.2	3.73	81
Syn 70-10	14	15.5	15.5	15.5	45.2	8.3	3.16	84
Syn 70-16	14	4.8	5.8	11.5	75.0	2.9	3.64	104
Talent	34	2.6	1.8	7.0	73.7	14.9	3.99	114
Tempo	7	8.4	6.5	5.6	75.7	3.7	3.60	107
Teton	26	7.1	1.2	1.2	65.5	25.0	4.05	84
Thor	21	4.2	4.2	6.2	81.2	4.2	3.77	48
Titan	32	14.5	5.8	8.7	69.6	1.4	3.37	69
Travois	26	1.2	0.0	5.8	81.4	11.6	4.02	86
TX-202	31	0.0	1.5	6.0	86.6	6.0	3.96	67
TX-407	31	3.3	1.1	3.3	83.7	8.7	3.94	92
TX-805	31	5.5	0.0	2.7	86.3	5.5	3.86	73
T3X-1	31	4.9	1.2	0.0	88.9	4.9	3.87	81
T3X-33	31	1.9	0.0	0.9	72.6	24.5	4.18	106
UC 60	13	7.8	4.7	10.9	67.2	9.4	3.67	64
Uinta	34	7.8	3.3	4.4	75.6	8.9	3.75	90
U 5045	25	1.1	3.4	4.5	78.7	12.4	3.99	89
U 5199	25	2.2	0.7	5.2	77.8	14.1	4.03	135
Vernal	34	4.1	4.1	8.9	72.4	10.6	3.88	123
Victoria	23	4.0	0.0	7.0	78.0	11.0	3.91	100
Warrior	21	6.2	1.6	3.1	75.0	14.1	3.91	64
Washoe	24	4.2	8.4	4.2	73.1	17.6	4.06	119
WA-S-2	11	14.0	8.0	6.0	70.0	2.0	3.33	50
Weevlchek	7	6.5	1.1	9.8	77.2	5.4	3.78	92
WL 210	4	9.1	1.3	6.5	76.6	6.5	3.70	77
WL 214	4	0.0	0.0	9.4	88.7	1.9	3.92	53
WL 215	4	7.2	4.8	12.0	69.9	6.0	3.63	83
WL 216	4	5.6	2.8	8.3	76.4	6.9	3.74	72
WL 217	4	4.5	0.0	4.5	73.9	17.0	4.00	88
WL 305	4	2.9	5.9	14.7	75.0	1.5	3.66	68
WL 306	4	7.7	2.6	6.4	79.5	3.8	3.69	78
WL 307	4	5.7	4.8	6.7	79.0	3.8	3.71	105
WL 308	4	6.3	2.1	10.5	76.8	4.2	3.70	95
WL 405	4	2.0	2.0	3.9	90.2	2.0	3.89	51
WL 450	4	4.0	3.0	7.9	84.2	1.0	3.75	101
WL 451	4	21.7	4.3	13.0	60.9	0.0	3.14	92
WL 504	4	8.9	8.9	11.1	66.7	4.4	3.50	90
WL 508	4	11.0	13.7	13.7	60.3	1.4	3.29	73
Zia	18	8.4	2.8	12.7	73.2	2.8	3.60	71
123	14	15.2	2.7	10.7	66.1	5.4	3.45	112
153	14	13.2	0.0	2.2	81.3	3.3	3.63	91
183	14	11.5	19.2	25.0	44.2	0.0	3.02	52
520	19	9.9	2.0	2.0	86.1	0.0	3.65	101
522	19	4.2	3.2	4.2	78.9	9.5	3.86	95
525	19	2.9	1.4	11.4	78.6	5.7	3.82	70
530	19	5.5	4.6	8.3	78.0	3.7	3.70	109

See footnotes at end of table.

Table 2.—Anthracnose resistance of alfalfa varieties and experimental strains, expressed as frequency distribution of plants in score classes and mean score—Continued

Variety or experimental strain	Source of seed[1] (code No.)	Percentage of plants in score classes[2] 1	2	3	4	5	Mean score	Number of plants tested
Checks								
Beltsville 1-An4[8]	34	76.5	8.2	1.0	7.1	7.1	1.66	98
Beltsville 2-An4[8]	34	69.0	8.6	8.6	12.1	1.7	1.69	58
Beltsville 3-An4[8]	34	76.9	11.5	3.8	7.7	0.0	1.41	78
MSA-CW3An3[9]	34	88.1	1.8	0.0	10.1	0.0	1.32	109
MSB-CW5An3[9]	34	84.4	3.1	2.1	10.4	0.0	1.39	96
Arc (MSHp6F-An4W4)	34	83.0	2.1	2.1	12.8	0.0	1.47	94
Cherokee	8	11.8	7.1	10.6	67.1	3.5	3.42	85
Saranac	34	2.1	1.1	5.3	77.9	13.7	4.01	95
Team	34	35.0	2.0	4.0	55.0	4.0	2.93	100
Williamsburg	9	3.4	0.0	5.7	85.1	5.7	3.90	87
Least significant difference (0.05)							0.35	
Least significant difference (0.01)							0.46	
Coefficient of variation (%)							7.0	

[1]Table 1 identifies code numbers given.
[2]Plants scored 1 to 5: 1 = highly resistant, 5 = dead.
[3]BIC = Beltsville International Composite.
[4]Syn N, Syn 2.
[5]Syn B, Syn 1.
[6]Syn H, Syn 1.
[7]Experimental population obtained from O. J. Hunt and selected for resistance to anthracnose at Beltsville, Md.
[8]Experimental population developed for resistance at Beltsville, Md. (*6*).
[9]Experimental population developed for resistance at Beltsville, Md. (*10*).

anthracnose. The other two strains (SW32-An3 and SW Comp.-An3) had been subjected to two generations of selection for anthracnose resistance at Beltsville, Md., and were moderately resistant. Team, 'Gemini', 'Luna', and '183' were significantly more resistant than the susceptible checks Cherokee, Saranac, and Williamsburg. Differences among entries in the frequency distributions by disease score class indicated differences in the gene frequencies controlling resistance and the mode of genetic control (*5*). The distributions of some entries, such as MSA-CW3An3 and MSB-CW5An3, were strongly bimodal, while others, such as SW32-An3 and SW Comp.-An3, had a greater percentage of plants in the intermediate score class.

Conclusions

The high degree of susceptibility in almost all the varieties or strains not selected specifically for anthracnose resistance requires explanation. Until recently the very costly damage resulting from anthracnose had not been appreciated, and the development of anthracnose resistance per se has not been an objective of alfalfa breeding programs. Most alfalfa varieties have been bred for adaptation to areas where alfalfa cultivation is most intense. These are primarily the Northern States with cool summers or the low humidity areas of the Southwest. Such areas are not favorable for the development of anthracnose epiphytotics, and thus field selection for adaptability in these environments would not be expected to include anthracnose resistance as a component of adaptation. Without this selection pressure, resistance would not be developed in strains produced in these areas. The increased use of Flemish germplasm in breeding programs has also contributed to the anthracnose problem. This germ-

plasm has desirable growth characteristics, but it is acutely susceptible to anthracnose.

It has not been the practice to produce alfalfa seed in the Eastern United States in such a manner as to develop locally adapted strains as has been the case with some forage species. Consequently, there has not been the opportunity to develop resistant strains by this route.

Sources of high anthracnose resistance were not available to breeders until 1970, when seven alfalfa populations with high anthracnose resistance were released by the Agricultural Research Service (*6*, *10*). Public and private alfalfa breeders can use these resistant releases in the development of resistant varieties adapted to local environments or use procedures now available to select specifically for anthracnose resistance in their own breeding stocks. Field tests indicate that anthracnose resistance results in marked increases in stand longevity, forage yield, and resistance to weed encroachment (*7*, *8*). In 1974, Arc was released cooperatively by the Agricultural Research Service and the Agricultural Experiment Stations of Maryland, North Carolina, Pennsylvania, and Virginia. Arc is highly resistant to anthracnose and moderately resistant to bacterial wilt. It is similar to Team in other respects but is more tolerant to alfalfa weevil feeding than Team. 'Saranac AR', developed from Beltsville 2-An4 (*6*), was also released in 1974 by the Agricultural Experiment Station of Cornell University. The incorporation of anthracnose resistance in additional varieties destined for marketing in the southern Corn Belt, middle-Atlantic States, and Southeastern States remains an important objective for alfalfa breeders.

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