

EFFECTS OF SELECTION FOR PHYTOPHTHORA  
ROOT ROT RESISTANCE IN NON-DORMANT ALFALFA

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INTRODUCTION

Alfalfa is a crop of major economic importance in California and Arizona. It is grown for forage on over 1,000,000 acres in California and occupies approximately 20 percent of the irrigated crop land in Arizona (2, 4). Cash value of alfalfa grown for forage in these two states is well over 300,000,000 dollars annually.

Phytophthora root rot (Phytophthora megasperma Drechs.) has long been recognized as a major problem in alfalfa production in California (1, 3). Dr. Don Erwin, at the University of California, Riverside reported the disease as early as 1954 in California (1). It was later reported to be a major problem of alfalfa in Arizona by Hine and others (2).

Many alfalfa research workers consider Phytophthora root rot to be the most important disease of alfalfa in California and Arizona today.

Work reported in this paper was done for three primary reasons:

1. To develop Phytophthora root rot resistant non-dormant alfalfa varieties.
2. To compare greenhouse and field selection techniques.
3. To estimate the forage yield potential of similar alfalfa lines possessing varying levels of Phytophthora root rot resistance, in the presence and absence of Phytophthora root rot.

MATERIALS AND METHODS

I Selection for Phytophthora Root Rot Resistance.

A. Field Selection Technique. Alfalfa lines were seeded in three row plots approximately 15 feet long with six inches between rows and twelve inches between plots in early April. Entries were replicated four times and seeding rate was 25 pounds per acre. Soil type was a clay loam. The nursery was sprinkle irrigated continually for approximately 36 hours and 12 hours daily thereafter for three days in early June. The nursery then received no water for 14-20 days and entries were rated visually after which they were clipped back. This procedure was repeated two more times.

Plants were dug and roots scored for disease symptoms in early September. Resistant plants were selected from desired lines and 75-130 resistant plants were used to advance a line to the next generation.

B. Greenhouse Selection Technique. Approximately 10,000 seeds of an alfalfa line to be screened for Phytophthora root rot resistance were planted in flats filled with Jiffy-mix. Approximately 500 seeds were planted in each flat. Seedlings were watered as needed and grown under optimum greenhouse conditions for approximately five weeks at which time they were inoculated with pure cultures of Phytophthora megasperma. Flats were then placed in level greenhouse benches lined with plastic. Water was put into the benches and brought up to a level that almost covered the top of each flat. This condition was maintained for one week after which all water was drained from the bench. Seedlings were watered as needed for three to four weeks. At this time, resistant seedlings were selected and transplanted to isolation cages for seed production. Again, 75-125 plants were used to advance a line to the next generation.

II. Comparison of Greenhouse and Field Selection Techniques.

Two experimental lines (K3-652 and Px-753) were screened in the greenhouse and field for resistance. The following year selected and parental lines were grown and compared in the field Phytophthora nursery as were appropriate check varieties.

### III. Forage Yield Estimates.

Forage yield was measured on parent lines, selected lines and check varieties in replicated trials at various locations in California and Arizona. Trials were replicated three or four times and harvested for two or three years.

## RESULTS AND DISCUSSION

### I. Development of Phytophthora Root Rot Resistant Lines of Non-Dormant Alfalfa.

By using one or more generations of mass screening for resistance to Phytophthora root rot, in the greenhouse or field, high levels of resistance were achieved in several lines (Table 1) and (Fig. 1).

### II. Comparison of Greenhouse and Field Selection Techniques.

The two alfalfa lines Px-753 and K3-652 were both screened for resistance to Phytophthora root rot in the greenhouse and field during 1975. The two Px-753 sister lines were designated Px-753 P<sub>1</sub>, gh (greenhouse selection) and Px-753 P<sub>1</sub>, F (field selection). The two K3-652 sister lines were designated K3-652 P<sub>1</sub>, gh and K3-652 P<sub>1</sub>, F. When the lines were compared to their respective parent lines and checks in the field Phytophthora nursery in 1976, it was found that either greenhouse or field selection techniques were equally effective in developing Phytophthora root rot resistant alfalfa lines (Table 2). Both methods appear to work equally well. The important aspect (with either technique) of selecting for Phytophthora resistance is to be certain test conditions are sufficient to prevent the selection of escapes. A plant breeder should use the technique that best fits his particular circumstances.

#### Relative Forage Yield of Similar Alfalfa Lines Possessing Varying Levels of Phytophthora Root Rot Resistance.

A. Woodland, California (A). Five pairs of lines and check varieties were compared for forage yield in a three year trial which was planted in September, 1975. Phytophthora root rot symptoms were observed in the trial during 1976. The only alfalfa lines in the trial that are susceptible to the disease were Moapa 69, K1-602 and K3-664. Yield performance of these three lines was inferior to the check Lahontan in 1976; the selected lines ranged from 102 to 116 percent of the check (Table 3).

Lines selected for high levels of Phytophthora resistance had five percent greater forage yield than their parental lines when averaged over three years (Table 3). The moderately resistant line K3-664 P<sub>1</sub> had nine percent greater forage yield than its parental line (K3-664) during the three year period. The line K1-602 was included as it is a non-dormant alfalfa with high yield potential in the absence of Phytophthora root rot. Its yield, like that of K3-664, was lower than yields of the Phytophthora resistant lines.

During the winter of 1977-78 stand losses were significant in this trial as a result of the very wet winter conditions. The specific cause of these stand losses was not known; however, it was not Phytophthora root rot. Stand losses were not quite as great for the Phytophthora selected lines, however improvement over their parental lines was only six percent (Table 3). The dormant check, Lahontan, held its stand well (89%) as did the intermediately non-dormant sister lines Px-753 (90%) and Px-753 P<sub>1</sub> (91%). All other lines were non-dormant and suffered substantial stand declines.

Under conditions which this trial was conducted, high or intermediate levels of Phytophthora resistance resulted in slightly improved stand persistence and forage yield. Phytophthora resistance coupled with a more dormant growth habit resulted in better stand retention than did high levels of disease resistance in non-dormant lines.

B. Woodland, California (B). Two sets of lines and check varieties were compared for forage yield in a three year trial which was planted in April, 1976. Phytophthora root rot symptoms were observed during 1976 and the selected lines were significantly higher in forage yield than their parental lines or check varieties. When averaged over the three years, selected lines were eleven percent higher in forage yield than their parental lines (Table 3).

C. Merced, California. Two sets of lines were compared to a check variety (Moapa 69) for three years. During the three year period Phytophthora selected lines were equal to and thirteen percent higher in forage yield than their parental lines. The two Phytophthora selected lines were seventeen and eleven percent higher in forage yield than Moapa 69 (Table 3).

Phytophthora root rot symptoms were never observed in this trial but in 1976 many entries suffered from an unidentified disease and Moapa 69 was quite susceptible to it. All three sister lines of K3-666 performed much better than did Moapa 69 as did Px-753 P<sub>1</sub>. The line K3-666 P<sub>1</sub> performed no better than its two sister lines; however Px-753 P<sub>1</sub> was superior to Px-753 (Table 3).

D. Bakersfield, California. One pair of lines was compared to a check variety (Moapa 69). The three year average yield of K3-666 P<sub>1</sub> was four percent greater than that of its parental line and neither was significantly different from the check (Table 3). Symptoms of Phytophthora root rot were never observed in this trial.

E. Yuma, Arizona. Two pairs of lines were compared for forage yield for a two year period. Phytophthora root rot symptoms were not observed in this trial. The two year average relative yield of the Phytophthora selected lines and parental lines was 97 and 100 percent respectively. This was the only instance where the parental lines produced more than the selected lines and this difference was not significant (Table 3).

F. Phoenix, Arizona. Two pairs of lines were compared during a two year period. Two year average forage yields of the selected lines were equal to yields of the two parental lines (Table 3). Again, no symptoms of Phytophthora root rot were observed in the trial.

A total of 14 lines selected for Phytophthora root rot resistance were compared to their parental lines for forage yield at three locations in California and two locations in Arizona. Parental lines ranged from susceptible to resistant to Phytophthora root rot. Selected lines were moderately resistant to highly resistant. Average yields of the selected lines in all trials for two and three years were four percent greater than yields of their parental lines.

The only location where Phytophthora root rot symptoms were observed was at Woodland. In these trials lines possessing some resistance to the disease were significantly superior to susceptible lines; however, resistant and highly resistant selections were only slightly superior to moderately resistant and resistant parental lines respectively (Table 3).

It is important that the Phytophthora resistant selections were not inferior to parental lines or checks in the absence of the disease. In most cases the selected lines (resistant and highly resistant to Phytophthora root rot) were slightly superior to their parental lines and checks in absence of obvious Phytophthora root rot problems.

The six yield trials discussed were managed as well as possible with respect to all factors including water management. Irrigation water was never allowed to stand on the trials. Had irrigation water been allowed to stand on the trials (as it often does in low spots in fields) yield advantages for Phytophthora resistant lines would undoubtedly have been greater.

I view Phytophthora resistance as one of several important disease factors in alfalfa production. Resistance to this disease is important and is certainly helpful, but it is not a "cure all".

#### LITERATURE CITED

- 1 Erwin, D. C. 1954. Root rot of alfalfa caused by Phytophthora cryptogea. *Phytopathology*. 44:700-704.  
Hine, R. B., F. A. Gray and M. H. Schonhorst. 1972. *Plant Disease Reporter*. 56:472-473.  
Lehman, W. F. and D. C. Erwin. 1974. The uses of land leveling, irrigation, and varieties in the reduction of summer stand decline of alfalfa in desert areas. *California and Arizona Low Desert Alfalfa Symposium*. PP 49-53.
- 4 Marble, Vern L. 1971. Introduction. *California Alfalfa Production Symposium*.

Table 1. Reaction of selected lines and check varieties to *Phytophthora megasperma* in field nurseries at Woodland and the University of Minnesota.

Line	Visual rating on <sup>1/</sup>	% resistant		Rating <sup>2/</sup>
	top growth	Woodland	Univ. Minn.	
Px-76-101	1.3	51.0	69.2	HR
Px-76-84	2.1	40.0	56.1	HR
Agate	-	-	34.8	R
Px-75-71	2.0	-	-	HR
Px-75-73	2.1	41.0	-	HR
Px-76-97	2.1	-	-	HR
Px-76-98	1.4	-	-	HR
Px-76-100	1.8	-	-	HR
Mesa Sirsa	7.5	.08	-	S
Lahontan	5.0	13.0	-	R
Moapa 69	6.2	2.0	-	S

<sup>1/</sup> Lines showing few or no disease symptoms rated 1. Lines completely dead rated 10.

<sup>2/</sup> HR = Highly resistant  
R = Resistant  
S = Susceptible

Table 2. Reaction of sister lines selected for resistance to *Phytophthora* root rot under greenhouse and field conditions in 1975, and respective parental lines. Reaction was estimated under field conditions during 1976.<sup>1/</sup>

Line	Visual rating <sup>2/</sup>	<i>Phytophthora</i> rating <sup>3/</sup>
Px-753	4.2	R
Px-753 P <sub>1</sub> , g.h.	2.0	HR
Px-753 P <sub>1</sub> , F	2.3	HR
Lahontan	5.0	R
Moapa 69	6.2	S
K3-652	4.8	R
K3-652 P <sub>1</sub> , g.h.	3.0	HR
K3-652 P <sub>1</sub> , F	2.1	HR
Lahontan	5.0	R
Moapa 69	6.2	S
LSD .05 =	1.11	

<sup>1/</sup> Values are averages of four replications rated three times.

<sup>2/</sup> Rated on scale of 1 to 10 with 1 being no damage and 10 completely dead.

<sup>3/</sup> HR = Highly resistant, R = Resistant, S = Susceptible.

Table 3. Relative forage yields and *Phytophthora* root rot ratings for alfalfa lines selected for *Phytophthora* root rot resistance, their respective parental lines and checks in California and Arizona.

Line	Phytophthora <sup>1/</sup> rating	Forage yield <sup>2/</sup>			$\bar{x}$	% stand 10-1-78
		1976	1977	1978		
<u>Location: Woodland, California (A)<sup>3/</sup></u>						
K3-643	R	116*	107*	96	106	63*
K3-643 P <sub>1</sub> , (F)	HR	115*	110*	102	109	74*
K1-602	S	83*	99	82*	88*	58*
K3-652	R	109	102	89	100	73*
K3-652 P <sub>1</sub> , (gh)	HR	112*	108*	100	107	76*
K3-666	MR	110	98	88*	99	76*
K3-666 P <sub>1</sub> , (gh)	R	106	103	102	104	79
Px-753	R	103	107	103	104	90
Px-753 P <sub>1</sub> (gh)	HR	108	105	109	107	91
K3-664	S	90*	106	89	95	60*
K3-664 P <sub>1</sub> (gh)	MR	102	106	103	104	64*
Moapa 69	S	81*	94	78*	84*	64*
Lahontan	R	100	100	100	100	89

Average relative yield of selected lines = 106%

Average relative yield of parental lines = 101%

Percent stand of selected lines = 76.2%

Percent stand of parental lines = 70.0%

Location: Woodland, California (B)<sup>3/</sup>

K3-643	R	116*	113*	102	110
K3-643 P <sub>2</sub> (F)	HR	130*	114*	106	117*
K3-643 SAA	R	107	110*	103	107
K3-666 SAA <sub>1</sub>	S	101	95	89	95
K3-666 P <sub>1</sub> (gh)	R	122*	108	106	112
K3-666	MR	110	99	99	103
Moapa 69	S	99	98	101	99
Lahontan	R	100	100	100	100

Average relative yield of selected lines = 115%

Average relative yield of parental lines = 104%

Location: Merced, California

K3-666 P <sub>1</sub> (gh)	R	107	118*	132*	117
K3-666 SAA <sub>1</sub>	S	114	118*	137*	120
K3-666	MR	106	119*	131*	117
Px-753 P <sub>1</sub> (gh)	HR	101	109	131*	111
Px-753	R	90	99	112	98
Moapa 69	S	100	100	100	100

Average relative yield of selected lines = 114%

Average relative yield of parental lines = 112%

Table 3. Continued.

Line	Phytophthora <sup>1/</sup> rating	Forage yield <sup>2/</sup>			$\bar{x}$	% stand 10-1-78
		1976	1977	1978		
<u>Location: Bakersfield, California</u>						
K3-666	MR	102	101	94	99	
K3-666 P <sub>1</sub>	R	99	107	105	103	
Moapa 69	S	100	100	100	100	
<u>Location: Yuma, Arizona</u>						
K3-664	S	91	100		96	
K3-664 P <sub>1</sub>	MR	98	102		100	
K3-643	R	102	100		101	
K3-643 P <sub>1</sub>	HR	96	90		93	
Mesa Sirsa	S	100	100		100	
Average relative forage yield of selected lines = 97%						
Average forage yield of parental lines = 100%.						
<u>Location: Phoenix, Arizona</u>						
K3-652	R	105	101		103	
K3-652 P <sub>1</sub>	HR	103	100		102	
K3-664	S	104	105		105	
K3-664 P <sub>1</sub>	MR	101	107		105	
Hayden	S	100	100		100	
Average relative forage yield of selected lines = 104%						
Average relative forage yield of parental lines = 104%						
Average relative forage yield of selections across all locations = 107%						
Average relative forage yield of parental lines across all locations = 103%						

<sup>1/</sup> S = susceptible, MR = Moderately resistant, R = resistant, HR = highly resistant.

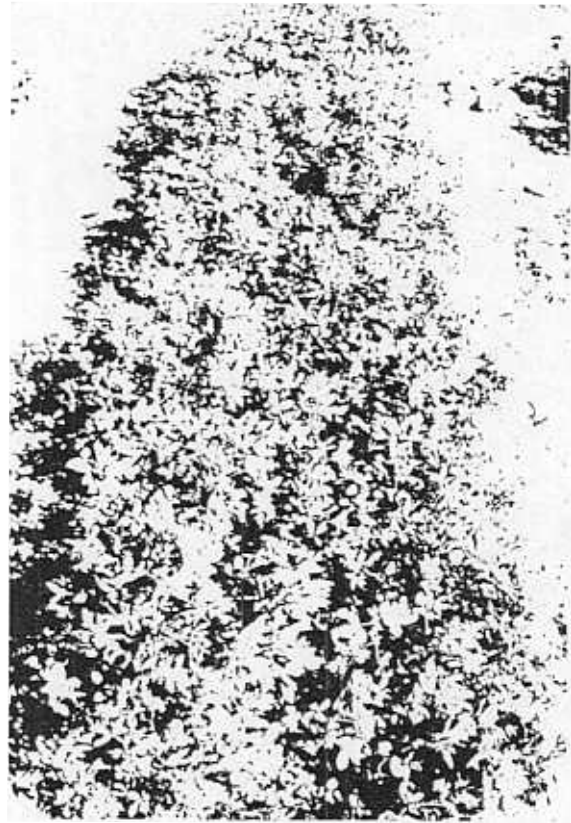
<sup>2/</sup> Forage yields are expressed as percent of check.

<sup>3/</sup> Phytophthora root rot symptoms were observed in this trial.

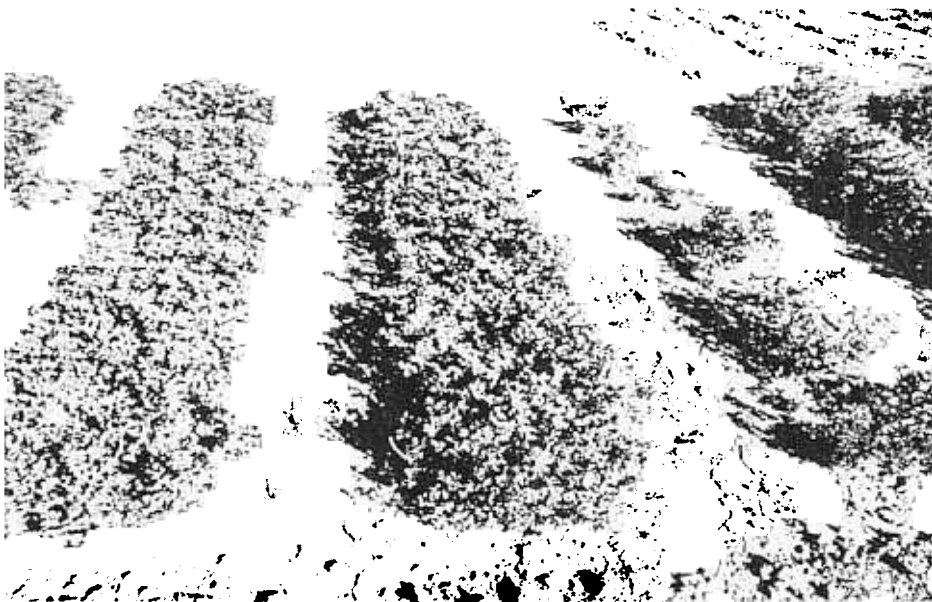
\* Significantly different from check at p = .05.



(1)



(2)



(3)

Figure 1. Phytophthora root rot resistant and susceptible alfalfa varieties:

- 1 - Susceptible check variety, Mesa Sirsa
- 2 - Highly resistant experimental alfalfa, PX-75-73
- 3 - Two highly resistant experimental lines and susceptible check variety, Lew