Yield to the Resistance:
The Impact of Nematode Resistant Varieties on Alfalfa Yield

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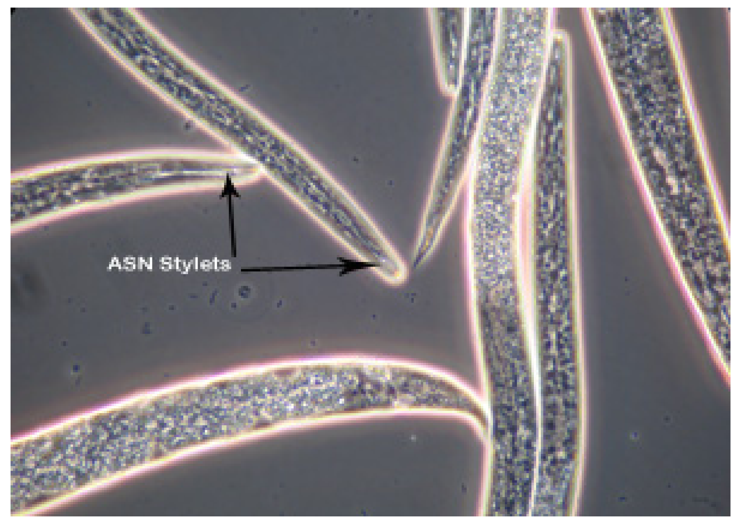
Alfalfa and Nematodes

Alfalfa is a critical cash crop in the western states and is susceptible to a pest known as the alfalfa stem nematode (ASN), (*Ditylenchus dipsaci*). Managing the ASN is vital so farmers can avoid economic losses due to decreased yield caused by the ASN.



ASN nematodes

One method to lessen economic losses incurred by ASN infestation is to use resistant varieties of alfalfa. Knowing how different resistant ratings affect harvest yield will be beneficial to alfalfa growers.

Healthy (left) vs infested (right) alfalfa

Resistant Varieties

The term resistance is used to describe the ability of a plant to suppress the internal development and reproduction of nematodes [3]. In alfalfa, a resistant variety has a phenotype that is different from some of the commonly grown varieties [4]. To find the relationship between resistant ratings and harvest yield we:

- wrote a system of difference equations
- fit the model to experimental data obtained in Weber County, UT
- assessed how different resistance ratings affect harvest yield

Resistant Ratings: Percentage of resistant seed used in field	
Percentage	**Resistance Class**
0-5%	Susceptible
6-14%	Low Resistance
15-30%	Moderate Resistance
31-50%	Resistance
>50%	High Resistance

The Model (Difference Equations)

S_t	Density of non-resistant nematode-free plants
I_t	Density of non-resistant nematode-infested plants
$\hat{S}_t$	Density of resistant nematode-free plants
$\hat{I}_t$	Density of resistant nematode-infested plants
W_t	Average density of nematodes in one plant's rhizosphere

$$S_t = S_{t-1}\overbrace{e^{-aW_{t-1}}}^{\text{probability to escape parasitism}}$$

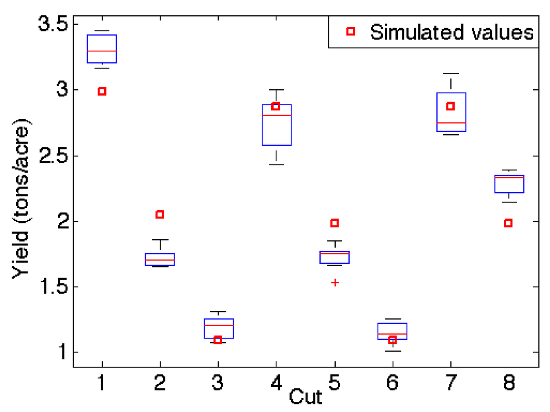
$$I_t = I_{t-1} + \overbrace{\left(1 - e^{-aW_{t-1}}\right)}^{\text{probability of parasitism}} S_{t-1}$$

$$\hat{S}_t = \hat{S}_{t-1}e^{-aW_{t-1}}$$

$$\hat{I}_t = \hat{I}_{t-1} + \left(1 - e^{-aW_{t-1}}\right)\hat{S}_{t-1}$$

$$W_t = \underbrace{(1-\mu_W)}_{\text{nematode survival}}W_{t-1} + \underbrace{CI_{t-1} + C\beta\hat{I}_{t-1}}_{\text{nematode immigration}}$$

Parameter Fitting



Data obtained in Weber County, UT

Parameter	Description	Estimated Value	Source
a	nematode search efficiency (area per nematode)	0.001	[1]
C	incoming nematode density per infested plant	1.202	[1]
μ_W	death rate of nematodes (density per time)	0.411	[2]
β	Reduction in nematode contribution from resistant plants	.1	This Work
γ	weight reduction in infested non-resistant plants (% grams)	0.38	This Work
λ	weight reduction in infested resistant plants (% grams)	0.15	This Work
g	approximate plant weight (grams)	11.5	This Work

Time unit is 30 days (approximate time between harvests).

Resistant Varieties and Harvest Yield

Alfalfa growers can benefit from knowing how each resistance class can affect the harvest yield of their field. Figure 1 shows model computations for growing alfalfa for 3, 4, 5, and 6 continuous years. It demonstrates how each resistant class will affect the yield based on how many years alfalfa is grown, which is, moving to a higher resistance class results in an increased harvest yield.

For each resistance class the relationship between time grown and total harvest yield is linear, suggesting that the total yield does not change from year to year. Thus, the average harvest yield per year for each resistance class is the same regardless of the length of time alfalfa is grown.

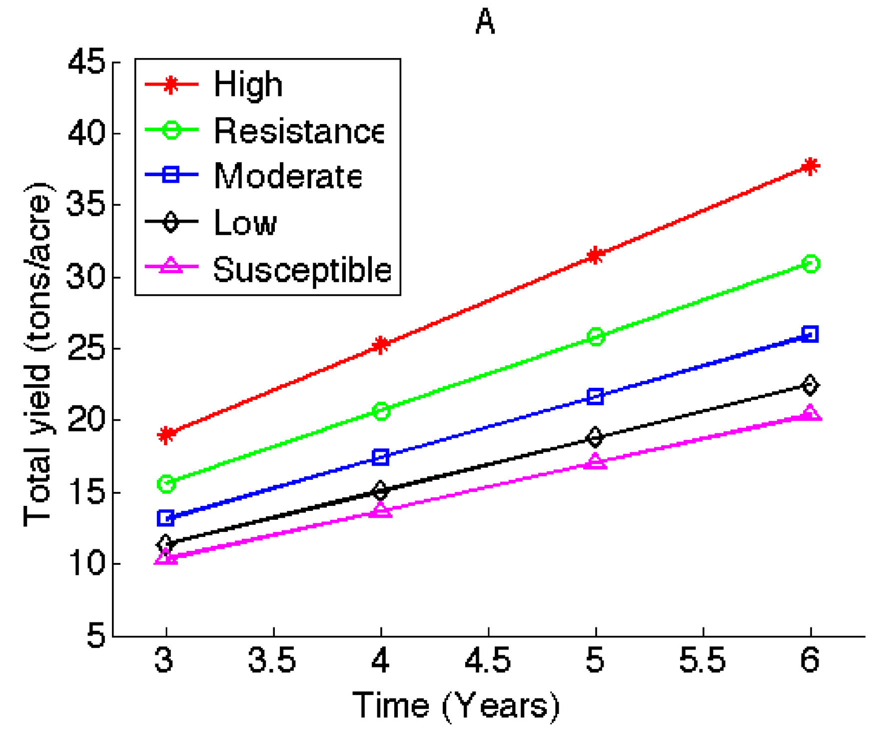


Figure 1: Total yield (tons/acre) for 3, 4, 5, and 6 years continuously growing alfalfa at different resistance ratings.

Conclusion

Percentage change in yield between resistant classes						
		To resistant class				
		Susceptible	Low	Moderate	Resistant	Highly
From resistant class	Susceptible	0%	10%	27%	51%	83%
	Low	-9%	0%	15%	37%	67%
	Moderate	-21%	-13%	0%	19%	45%
	Resistant	-33%	-27%	-16%	0%	22%
	Highly	-45%	-40%	-31%	-18%	0%

Table 1: Percentage change in yield (tons/acre) between different resistant classes of alfalfa. Table shows changes by going from the resistant class in left column to the resistance class along top row.

Crop management strategies can be improved by observing the impact of different resistant classes on harvest yield. Table 1 shows the average percentage change in yield (tons/acre) per year when changing from one resistant class to another. Changing from the susceptible class to the resistant class can approximately double the harvest yield during the growing season.

The model can be adapted to include other important characteristics that have an impact on ASN management. Such as including spatial-spread to predict how the nematode infestation will propagate throughout a field.

References

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[2] R.H. Boelter, F.A. Gray, R.H. Delaney (1985). Effect of *Ditylenchus dipsaci* on alfalfa mortality, winterkill, and yield. Journal of Nematology, 17(2), 140.

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[4] Cook, R., and Star, J.L., Resistant Cultivars in Plant nematology. Perry, R. N., and Moens, M. (Eds.) (2006) CABI