Managing Foliar Fungicide Applications in Reduced-Lignin Alfalfa Systems

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Fungicide Use on Alfalfa

- 1988 study – Some fungicide applications resulted in lower disease severity
- This resulted in higher yield in some treatments
- Products were contact (copper hydroxide and mancozeb) and acropetal penetrant (benomyl) fungicides

TABLE 1. Mean foliar disease severity, defoliation index, hay yield, and final stand density for groups of fungicide:application schedule treatments applied to ten consecutive harvests of Phytor alfalfa from 1983 to 1985

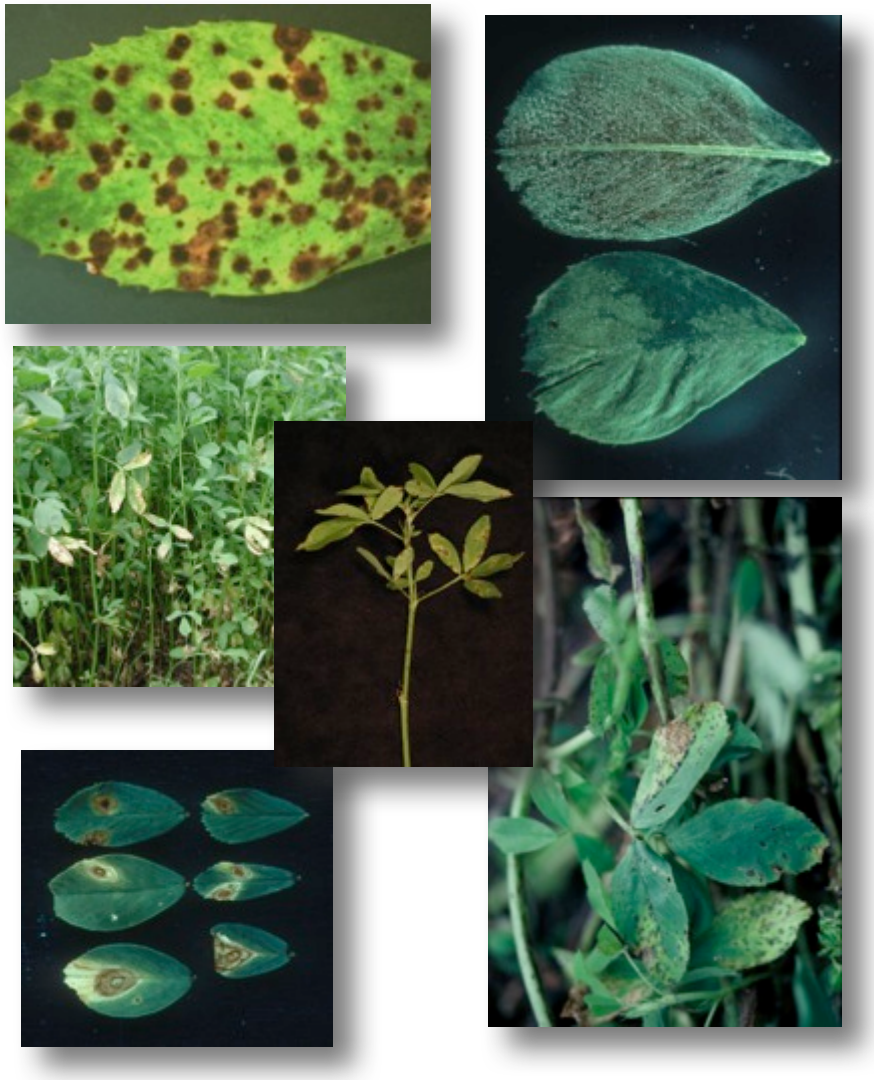
Treatment group	Foliar disease severity (%)	Defoliation index[a]	Hay dry matter yield (Mg/ha)	Final stand density (plants/m^2)
BE, ME[b]	4.0	0.46	4.02	81
BL, ML	4.8	0.46	3.84	67
B2, M2	2.7	0.44	4.08	90
B3, M3	2.2	0.43	4.20	103
CuL, Cu2	4.6	0.48	3.80	76
ML, M2	2.2	0.45	3.94	82
BE, BL, B2, B3	3.9	0.46	4.00	82
ME, ML, M2, M3	3.0	0.44	4.04	88
Single-degree-of-freedom contrast		Analysis of variance		
ME, BE vs ML, BL	**[c]	**	**	**
ME, BE vs M2, B2	**	ns	ns	ns
ML, BL vs M2, B2	**	*	**	*
M2, B2 vs M3, B3	*	ns	*	ns
ML, M2 vs CuL, Cu2	*	**	**	ns
BE, BL, B2, B3 vs Me, ML, M2, M3	**	**	ns	ns

[a] Defoliation index = length from stem base to lowest leaf attached to main stem/total stem length.
[b] Treatment abbreviations are a fungicide:application schedule combination. B, Cu, and M = benomyl, copper hydroxide, and mancozeb, respectively. E, L, 2, and 3 = application 26; 10; 26 and 10; and 26, 18, and 10 days before harvest, respectively.
[c] * and ** = contrast significant at $P = 0.05$ and 0.01, respectively. ns = contrast not significant ($P = 0.05$).

Broscious, S.C. and Kirby, H.W. (1988)

Foliar Disease of Alfalfa

- Common leaf spot (caused by *Pseudopeziza medicaginis*)
- Downy mildew (caused by *Peronospora trifoliorum*)
- Leptosphaerulina leaf spot (caused by *Leptosphaerulina briosiana*)
- Spring black stem (caused by *Phoma medicaginis*)
- Summer black stem (caused by *Cercospora medicaginis*)
- Stemphylium leaf spot (caused by *Stemphylium botryosum*)



Images from the “Compendium of Alfalfa Diseases”

Foliar Diseases of Alfalfa

Adverse effects on alfalfa

- Can damage leaves and stems = possible loss in quality
- Can result in defoliation = possible loss in yield and quality
- Can cause plant stress

Alfalfa dairy production in Wisconsin

- Often short cutting schedules ~ 30 days
- Foliar diseases often don't appear until near cutting time
- Defoliation is often minimal = very small affect on quality
- Occasionally a slight yield effect

Headline® Fungicide Label

- FRAC group 11; QoI or strobilurin fungicide; very limited mobility in the plant (local penetrant)
- One of the first strobilurin fungicides labeled for Alfalfa
- Not labeled for clover, grasses, or other perennial forage crops(e.g. not for mixtures of alfalfa and other grasses)
- 14 day pre harvest interval = 1 spray per cutting
- Allowed up to 3 applications per year
  - 6 to 9 fl oz./ acre per application
  - **$21 to $31/acre for just the fungicide product**
  - Maximum total of 27 oz./ acre per year

Quadris® Fungicide Label

- FRAC group 11; QoI or strobilurin fungicide; some mobility in the plant (acropteal penetrant)
- One of the first strobilurin products labeled for plant disease control
- Labeled for clover, grasses, or other perennial forage crops(e.g. mixtures of alfalfa, clover, or grasses)
- 14 day pre harvest interval = 1 spray per cutting
- Allowed up to 3 applications per year
  - 6 to 15.5 fl oz./ acre per application
  - **$17 to $44/acre for just the fungicide product**
  - Maximum total of 46.5 oz. / acre per year
  - **Generics now available for this active ingredient - $8/acre?**

Priaxor® Fungicide Label

- New for 2016 in Wisconsin
- FRAC group 11; QoI fungicide + SDHI
- Not labeled for clover, grasses, or other perennial forage crops(e.g. not for mixtures of alfalfa and other grasses)
- 14 day pre harvest interval = 1 spray per cutting
- Allowed up to 3 applications per year
  - 4 to 6.9 fl oz./ acre per application
  - **$18 to $31/acre for just the fungicide product**
  - Maximum total of 20.7 oz. / acre per year

2016 Foliar Fungicide Efficacy Trial – Arlington, WI

(28-30 day Cutting Interval)

Treatment and rate/A (crop harvest spray application)	Leaf Spot Average Severity (%, Crop 1-3)[y, x]	Average Defoliation (%, Crop 1-3)[y]	Total Dry Matter Yield (Tons/a)[w]
Non-treated Check	3.4 a	0.6	4.7
Serenade ASO 32.00 fl oz (Crops 1-3)	3.0 a	0.6	4.4
Aproach 2.08SC 9.00 fl oz[z] (Crops 1-3)	1.5 b	0.2	4.2
Headline 2.09SC 6.00 fl oz[z] (Crops 1-3)	1.4 b	0.2	4.9
Aproach 2.08SC 6.00 fl oz[z] (Crops 1-3) Fontelis 1.67SC 16.00 fl oz[z] (Crop 2)	1.1 b	0.0	4.7
Aproach 2.08SC 6.00 fl oz[z] (Crops 1-3)	1.0 b	0.2	4.5
Quadris 2.08SC 6.00 fl oz[z] (Crops 1-3)	0.8 b	0.0	4.6
LSD (α=0.05)	1.0	ns[v]	ns[v]

2011-2014 Studies
(30-day duration, Conventional Alfalfa)

- Large number of observations with Headline® (n=52) fungicide, followed by a few with Quadris® fungicide (n=12)
- Used meta-analysis (widely used in medical research) to compare a specific treatment response to the non-treated across many trials and observations – **can make predictions of future responses based on the results**
- Uses mean difference in treated vs. non-treated within each trial AND the trial variance to measure the effect on a large scale
- Looked at
  - Frequency distributions
  - Mean yield advantage
  - Considered variation across a field
  - Calculated Odds of a Positive ROI

Meta-Analysis Results for Headline® and Quadris® (Not partitioning by cutting)

	Yield Advantage Over Not Treating					
	K	Mean Difference from Non-treated	SE	*P*	CL Lower	CL Upper
Headline®	52	0.11 tons	0.02	<0.01	0.07	0.15
Quadris®	12	0.05 tons	0.03	0.12	-0.01	0.10

	RFQ Advantage Over Not Treating					
	K	Mean Difference from Non-treated	SE	*P*	CL Lower	CL Upper
Headline®	49	2.85	2.11	0.17	-1.28	6.98
Quadris®	9	5.68	3.48	0.10	-1.15	12.51

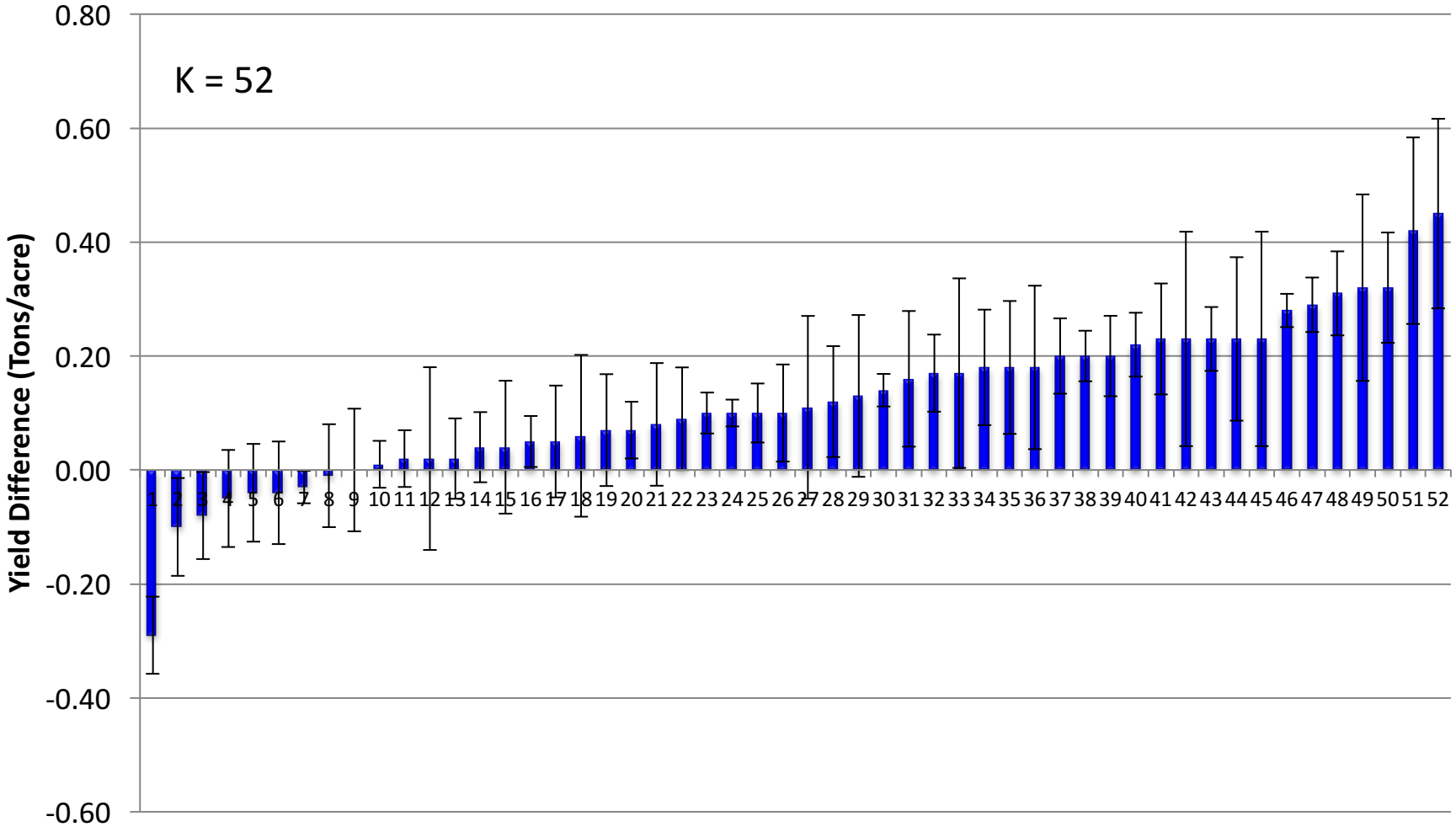
*Purposes of these analyses are to identify differences that are significantly greater than zero

Break-Even Scenarios for Alfalfa (Tons/A)

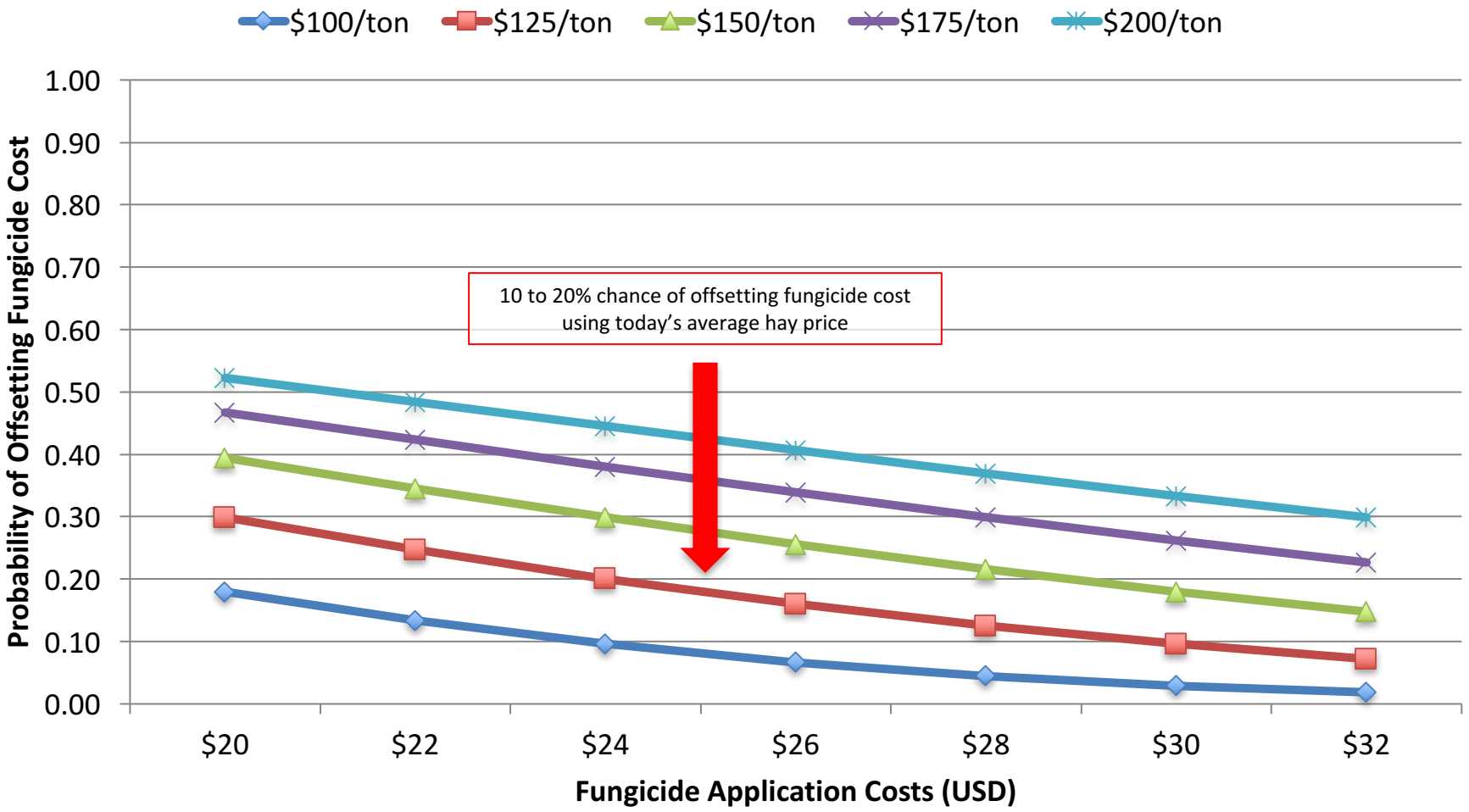
Fall 2016 Average Price
Large round bale (Prime Grade)

	Fungicide Application Cost ($/A)				
Alfalfa ($/Ton)	**$22**	**$24**	**$26**	**$28**	**$30**
$100	0.22	0.24	0.26	0.28	0.30
$125	0.18	0.19	0.21	0.22	0.24
$150	0.15	0.16	0.17	0.19	0.20
$175	0.13	0.14	0.15	0.16	0.17
$200	0.11	0.12	0.13	0.14	0.15
$225	0.10	0.11	0.12	0.12	0.13
$250	0.09	0.10	0.10	0.11	0.12
$275	0.08	0.09	0.09	0.10	0.11

Yield Difference Between Alfalfa Treated with Headline® Fungicide or Not Treated



Probability that a Headline® Fungicide application WILL offset the fungicide application costs



Summary

- In alfalfa for dairy production (30-day cutting interval) in Wisconsin, with low levels of disease, application of fungicide (specifically Headline®) :
  - Will result in highly variable yield and RFQ responses
  - Does sometimes result in a increase in yield over not treating when using Headline® (0.11 tons/a)
  - Will pay for itself about 10 to 20% of the time using today's prices
- Response to application of fungicide in alfalfa with longer cutting durations might be different
  - more disease pressure
  - Reduced-lignin systems and implications?

What about Longer Cutting Durations?

Midwest Forage Association Funded Research (2015 & 2016)
Full Report Available at: http://fyi.uwex.edu/fieldcroppathology/research-summaries/

- Used reduced-lignin alfalfa (HarvXtra)
- Compared to conventional RR alfalfa (DKA44-16RR)
- Eight Fungicide treatments
- Two cutting durations (30-day vs. 40 day)
- Single crop analyzed (seedling year) in 2015 (August)
- Three crops analyzed together in 2016 (June, July, and August)

Fungicide Treatments

Fungicide Product (active ingredient)	Rate per acre
Aproach (picoxystrobin)[1,2]	6 fl oz
Aproach (picoxystrobin)[1,2]	12 fl oz
Fontelis (penthiopyrad)	1.5 pt
Aproach (picoxystrobin)[1] + Fontelis (penthiopyrad)	6 fl oz + 14 fl oz
Priaxor (pyraclostrobin + fluxapyroxad)[2]	4 fl oz
Headline (pyraclostrobin)[2]	6 fl oz
Quadris (azoxystrobin)[2]	6 fl oz

[1]Denotes an 'experimental' treatment, not yet labeled for use on alfalfa in Wisconsin in 2016
[2]Treatment included the adjuvant, Induce 90 SL, at 0.3% v/v.

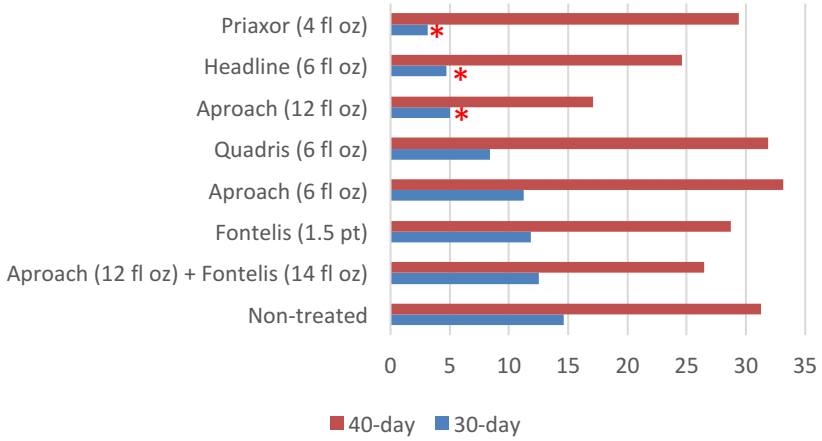
Initial Results

- No strong differential varietal response to fungicides
  - Conventional and Reduced Lignin tended to respond to treatments similarly
  - HarvXtra may be slightly more disease tolerant
- Responses to fungicide significant in second crop only in the seeding-year (2015)
- Quality responses in the long-duration (40-day) cutting treatments were driven by variety (primary effect) and fungicide (secondary effect)
  - 30-day cutting duration resulted in little difference in quality between both varieties and among fungicide treatments

Disease Severity (%)

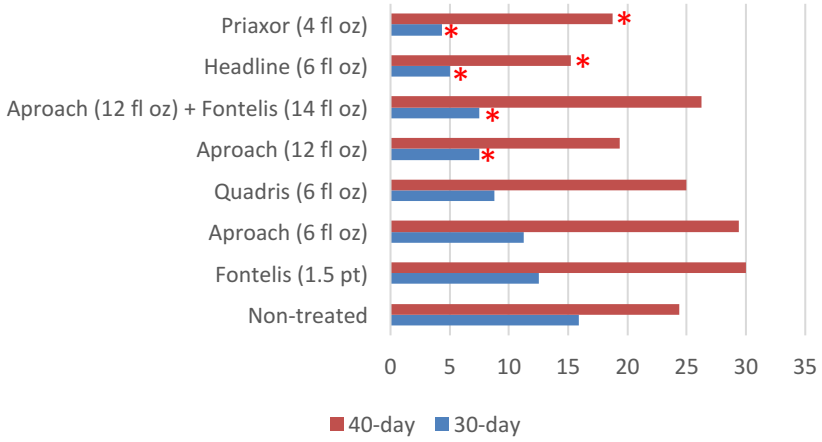
2015

DKA44-16RR



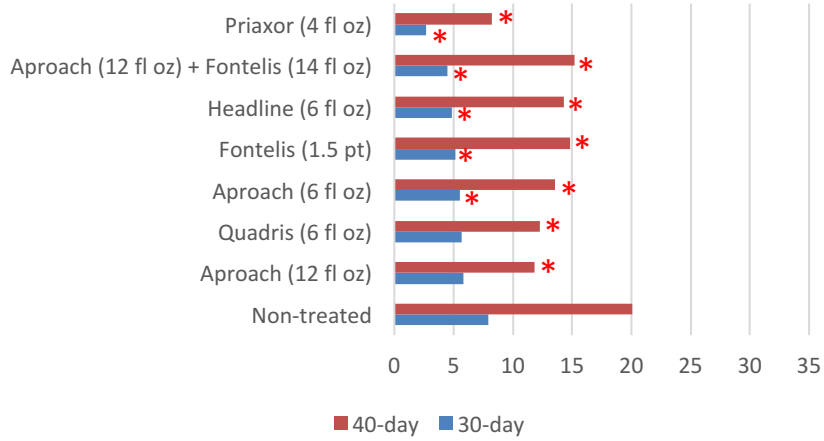
* Indicates significantly better than not treating, within each duration ($P \leq 0.05$)

HarvXtra



2016

DKA44-16RR



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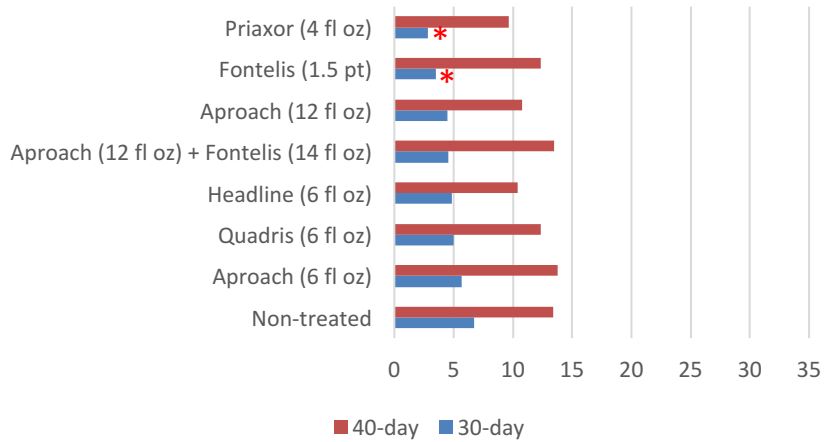
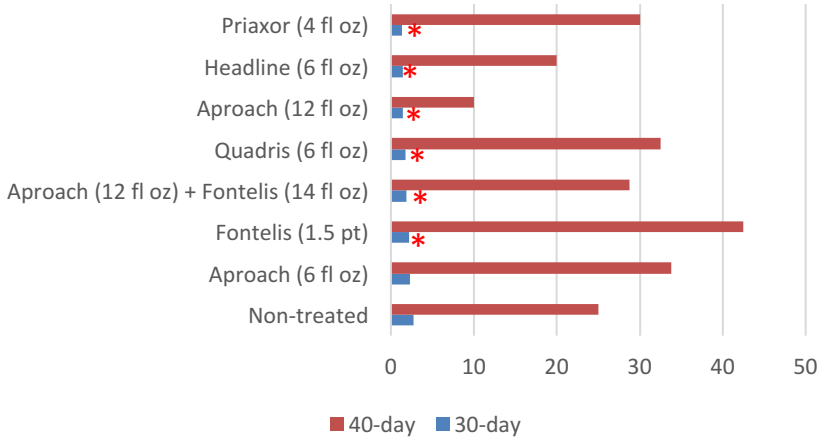
HarvXtra



Defoliation (%)

2015

DKA44-16RR



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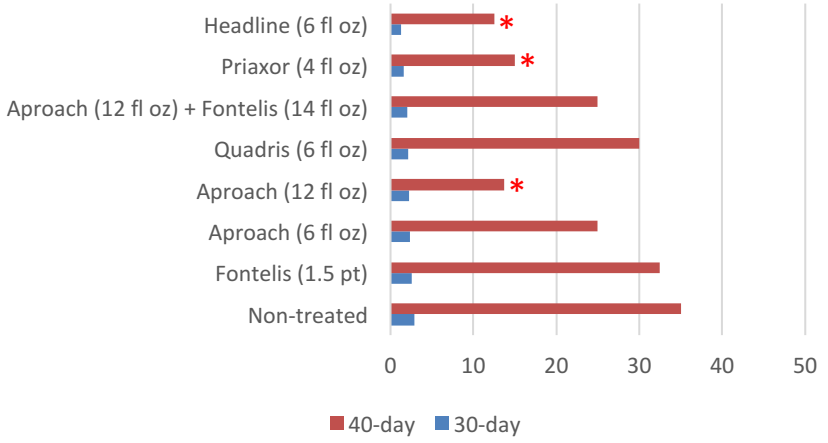
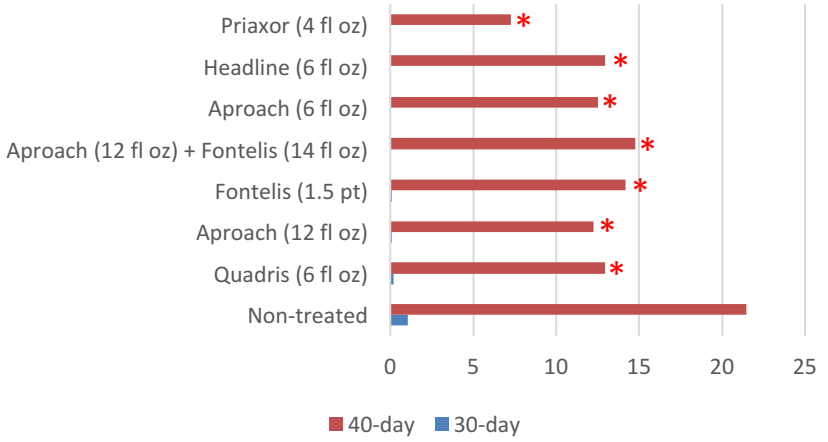
HarvXtra



2016

DKA44-16RR



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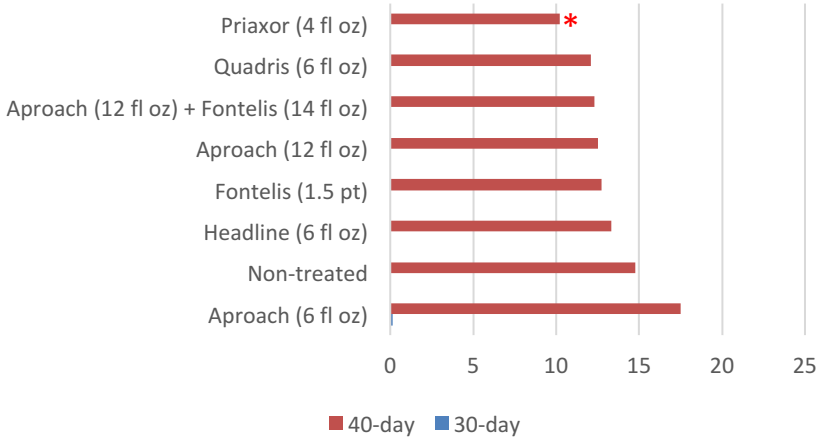
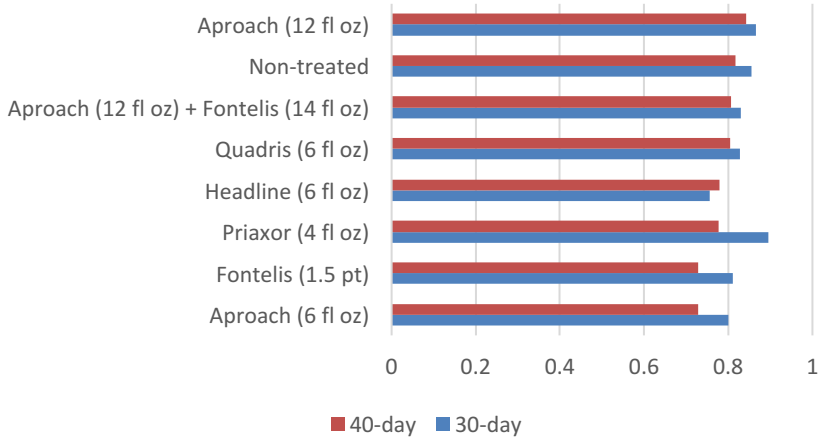
HarvXtra



Yield (tons/acre)

2015

DKA44-16RR



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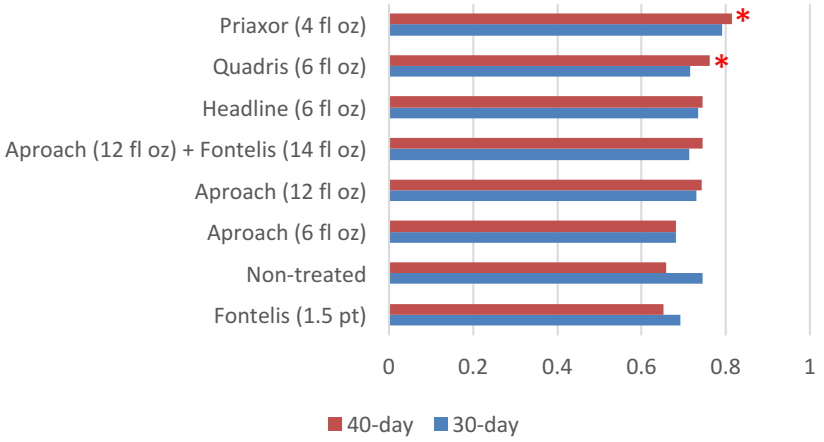
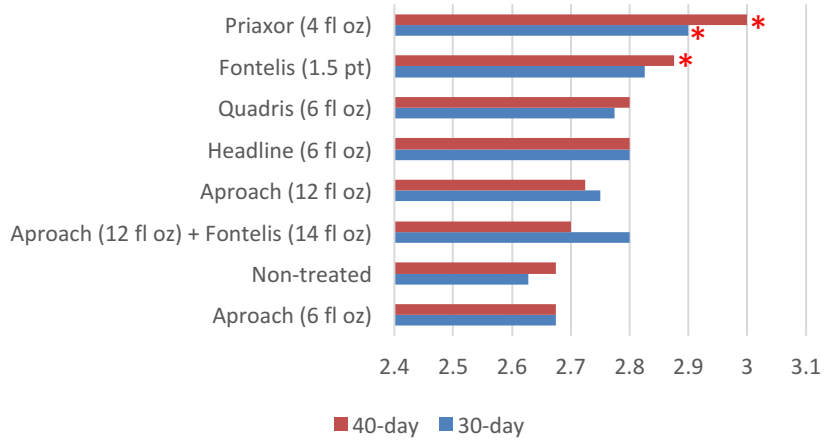
HarvXtra



2016

DKA44-16RR



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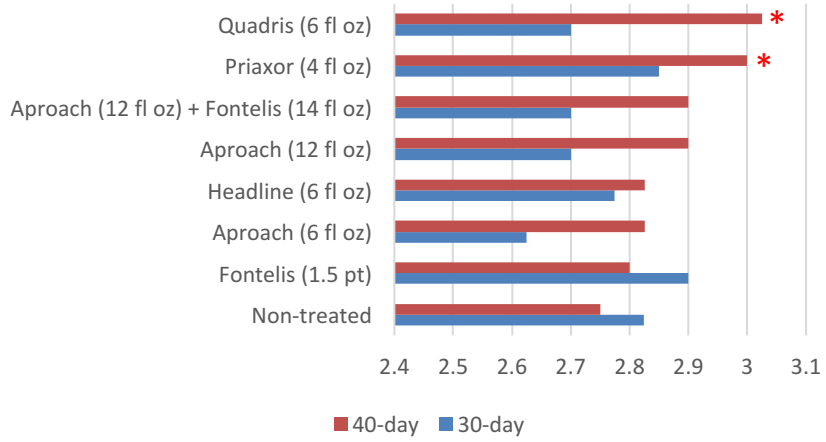
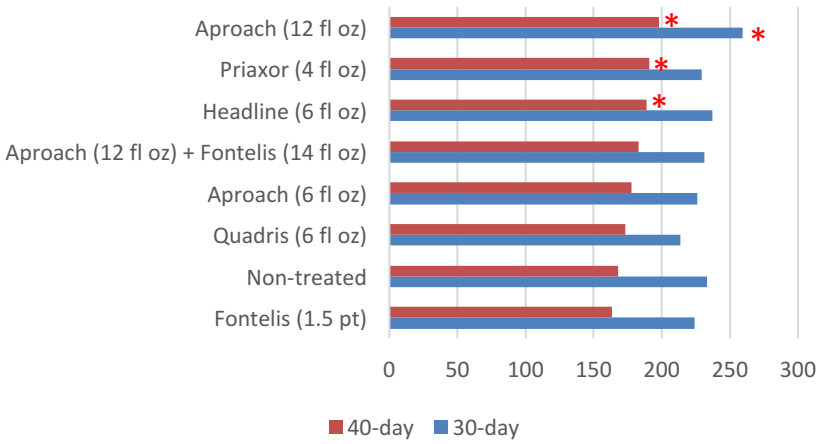
HarvXtra



RFQ

2015

DKA44-16RR



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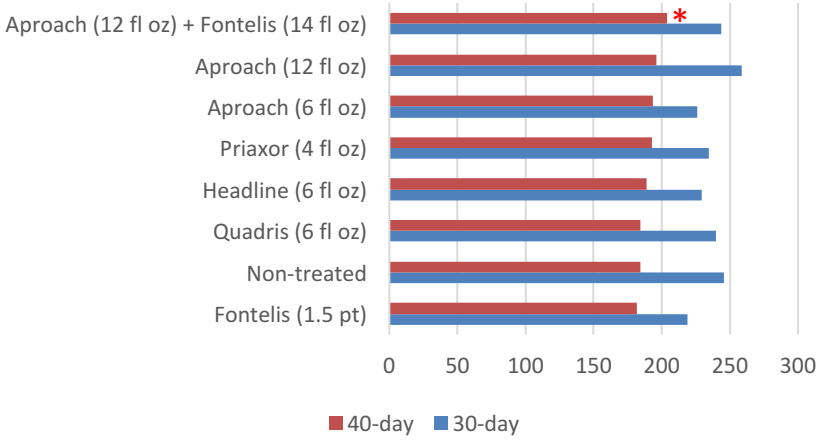
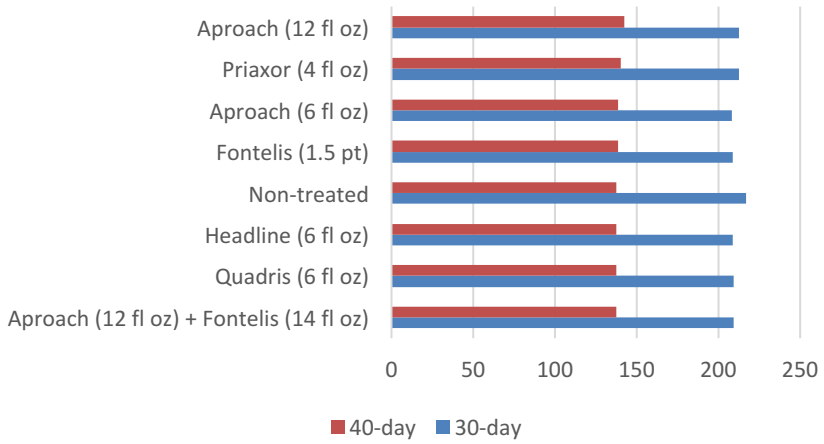
HarvXtra



2016

DKA44-16RR



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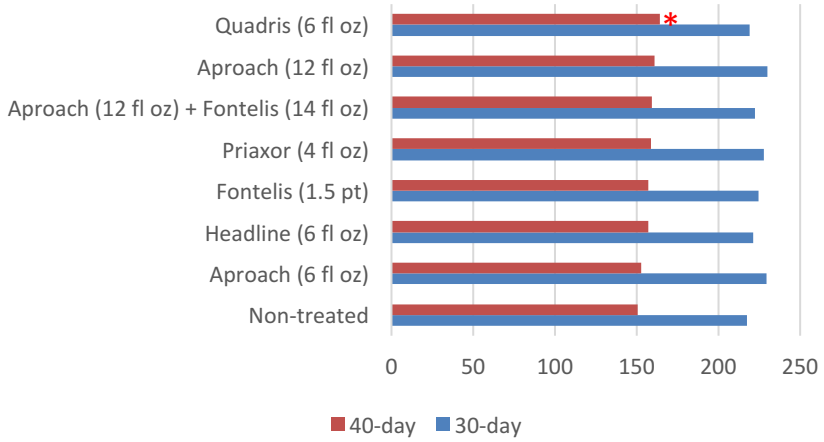
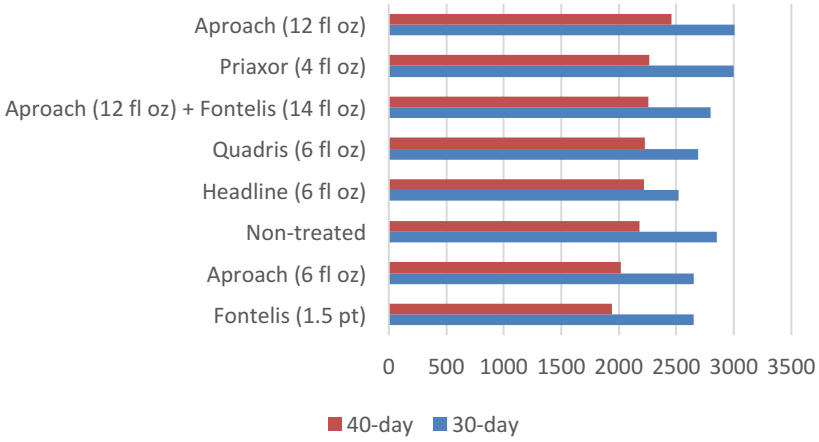
HarvXtra



Milk per acre (lbs.)

2015

DKA44-16RR



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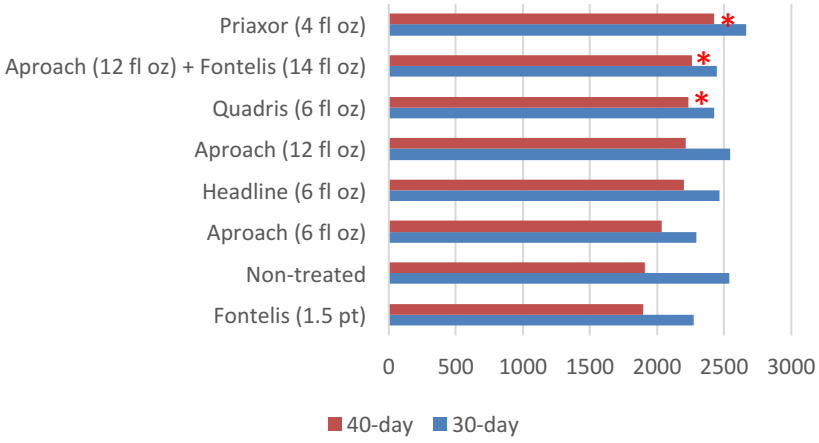
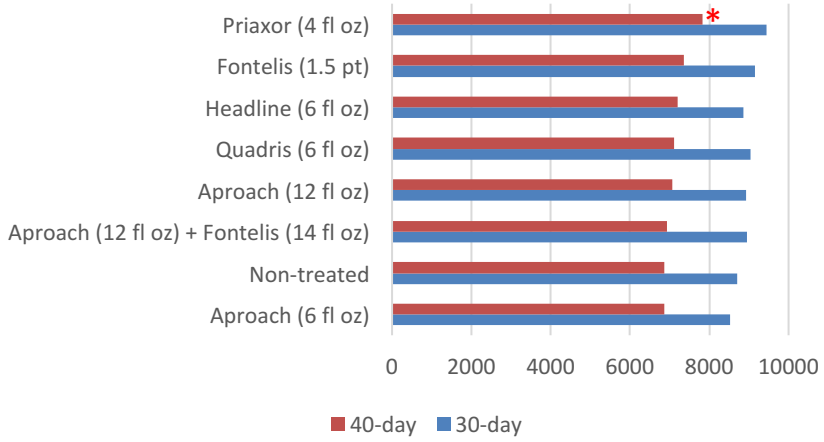
HarvXtra



2016

DKA44-16RR



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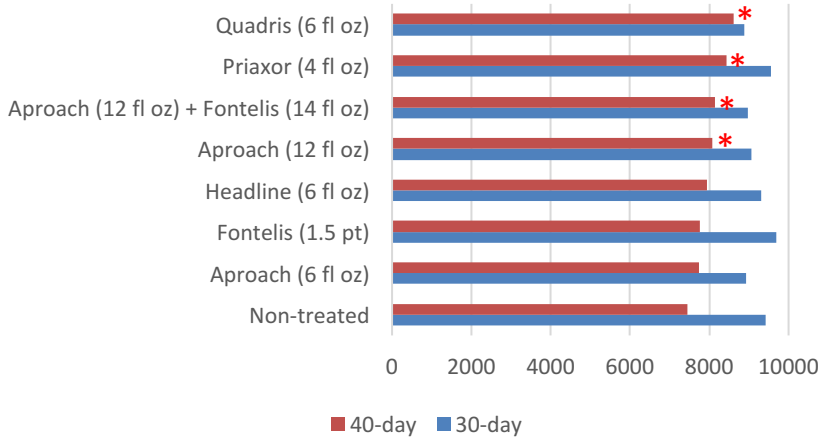
HarvXtra



Return on Investment

2015

Hay ROI With 1 Fungicide Application

	DKA44-16RR			HarvXtra		
	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)
30-day cutting Interval	($53.78)	($25.09)	($31.49)	($40.08)	($27.06)	($35.36)
40-day Cutting Interval	($41.91)	($40.29)	($28.64)	($21.55)	($6.16)	($9.71)

Milk ROI With 1 Fungicide Application

	DKA44-16RR			HarvXtra		
	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)
30-day cutting Interval	($93.27)	($7.64)	($55.02)	($51.05)	($14.21)	($49.29)
40-day Cutting Interval	($27.21)	($17.47)	($17.76)	$13.24	$55.16	$27.95

Assumptions for Calculations

- Summer 2015 Average Hay Price = $190/ton
- Summer 2015 Average Milk Price = $17.50 cwt
- HarvXtra Seed = $593/unit
- DKA44-16RR Seed = $412/unit
- Headline fungicide application = $20/a
- Priaxor fungicide application = $18/a
- Quadris fungicide application = $12/a
- Ground application fee = $7/a

2016

Hay ROI With 3 Fungicide Applications

	DKA44-16RR			HarvXtra		
	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)
30-day cutting Interval	($81.21)	($56.94)	($60.15)	($134.42)	($114.65)	($122.36)
40-day Cutting Interval	($89.58)	($47.31)	($64.02)	($112.15)	($74.38)	($50.59)

Milk ROI With 3 Fungicide Application

	DKA44-16RR			HarvXtra		
	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)	Headline (6 fl oz)	Priaxor (4 fl oz)	Quadris (6 fl oz)
30-day cutting Interval	($85.44)	$14.53	($33.88)	($144.37)	($95.89)	($187.25)
40-day Cutting Interval	($56.55)	$52.79	($48.71)	($46.91)	$40.93	$89.00

Assumptions for Calculations

- Summer 2016 Average Hay Price = $180/ton
- Summer 2016 Average Milk Price = $16.47 cwt
- HarvXtra Seed = $593/unit
- DKA44-16RR Seed = $412/unit
- Headline fungicide application = $20/a
- Priaxor fungicide application = $18/a
- Quadris fungicide application = $12/a
- Ground application fee = $7/a

2016 Large Plot Trial

- Arlington ARS
- Collaborators
  - Mike Bertram, UW ARS
  - Vince Davis, BASF
- Two Treatments (applied with commercial sprayer)
  - Non-treated
  - Priaxor @ 4 fl oz
- Three replications of each strip
- Three crops
  - Crops 2-4
- Pioneer 55V50 (conventional)
- Plot Size: 1500' x 45' (1.55 acres)
- Data
  - Disease ratings (Smith Field Crew)
  - Defoliation (Smith Field Crew)
  - Harvested yield (commercial equipment)
  - Quality data (Marshfield Forage Lab)

2016 Large Plot Trial

28-days

Cut 2	Disease Severity (%)	Defoliation (%)	Yield (Tons/a)	RFQ	Milk Per Ton (lbs.)	Milk Per Acre (lbs.)	Milk ROI (per acre)	Hay ROI (per acre)
Check	15.8	10.8	1.3	175.6	3127.5	4079.6		
Priaxor	9.7	3.6	1.4	174.6	3127.3	4215.7	($3.58)	($17.00)
F-value	5.38	51.71	2.68	0.01	0.00	24.41		
Pr>F	0.15	0.02	0.24	0.92	0.99	0.04		

34-days

Cut 3	Disease Severity (%)	Defoliation (%)	Yield (Tons/a)	RFQ	Milk Per Ton (lbs.)	Milk Per Acre (lbs.)	Milk ROI (per acre)	Hay ROI (per acre)
Check	11.8	5.6	1.3	165.0	2966.1	3785.7		
Priaxor	0.8	0.0	1.4	178.3	3099.5	4252.5	$50.88	($8.00)
F-value	64.49	21.00	1.17	4.23	10.49	3.25		
Pr>F	0.01	0.04	0.39	0.18	0.08	0.21		

42-days

Cut 4	Disease Severity (%)	Defoliation (%)	Yield (Tons/a)	RFQ	Milk Per Ton (lbs.)	Milk Per Acre (lbs.)	Milk ROI (per acre)	Hay ROI (per acre)
Check	19.2	52.0	1.3	138.3	2688.7	3491.6		
Priaxor	9.3	20.6	1.5	145.1	2813.1	4276.9	$103.35	$13.60
F-value	15.49	18.24	46.28	1.22	3.30	32.37		
Pr>F	0.06	0.05	0.02	0.38	0.21	0.03		

Total	Disease Severity (%)	Defoliation (%)	Yield (Tons/a)	RFQ	Milk Per Ton (lbs.)	Milk Per Acre (lbs.)	Milk ROI (per acre)	Hay ROI (per acre)
Check	15.6	22.8	3.9	159.6	2927.4	11355.0		
Priaxor	6.6	8.1	4.2	166.0	3013.3	12780.0	$156.70	$40.60
F-value	30.71	27.66	15.57	0.89	2.52	140.46		
Pr>F	0.03	0.03	0.06	0.44	0.25	<0.01		

Summary

Be selective when making the decision to use fungicide on alfalfa

- Short duration cutting (e.g. ≤ 30 days) will result in mixed ROI outcomes when foliar fungicide is used
  - Conventional and HarvXtra
- Longer duration cutting (e.g. ≥ 35 days) will result in higher likelihood of positive ROI when fungicide is used
  - Especially for milk production on farm
  - Conventional and HarvXtra
  - Supported by previous data by Duthie and Campbell (Phytopath. 1991)
- For reduced lignin alfalfa (HarvXtra) make your cutting
  - Use fungicide if the plan is to extend the cutting duration past 30-35 days (preserve yield potential and quality)
  - Save on the fungicide input if the plan is to harvest in a typical short duration system (30 days or less) – Disease pressure will generally be low and quality high

Questions?

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