Harvest and Cultivar Strategies to Improve Sustainability of Alfalfa (Medicago sativa L.) Cropping Systems

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Background

Alfalfa (*Medicago sativa* L.) is widely considered to be a highly sustainable crop due to its biological characteristics:

- Deep roots for water conservation and nutrient cycling
- High levels of rhizosphere biological activity improving soil microbiome health and tilth
- Protein from biological N_2 fixation without fossil-fuel-requiring N fertilizers
- Contribution to N in rotation with cereals
- Prevention of soil erosion
- Contribution to biological diversity, especially insects and wildlife habitat
- Sequestration of carbon

Mundane practices such as alfalfa harvest schedule or variety selection are rarely considered within the context of improved sustainability.

- Could modification harvest and cultivar strategies contribute to the sustainability of alfalfa?

Research

Field research was conduced over 4 years in the Mediterranean climate of the San Joaquin Valley of California on a sandy-loam soil to examine the interactions between harvest schedule and cultivars improved for quality. This is a long-season high-yield irrigated environment with typically ~7-9 harvests per year, Fall Dormancy (FD) Ratings 6-9.

Harvest Schedules: 'Normal' = typical 28-day schedule (balance yield/quality); 'Late' = high yield strategy. 'Staggered' strategy alternates a 21-d followed by 35-d days to allow a stream of high and low quality harvests over the season.

Schedule	Days between cuts	Cuts/Year (ave.)
'Normal'	28	7-8
'Staggered'	21-35	7-8
'Late'	35	5-6

Cultivars: Four conventional lines were compared with lines bred for higher quality. HarvXtra® for reduced lignin (GE trait), and HiGest (bred conventionally).

Name	Fall Dormancy	Type
RRAlf6R200	6	Control
SW6330	6	Control
DKA84-10RR	8	Control
SW9720	9	Control
H0615T514	6	HarvXtra[1]
RRL913T4	9	HarvXtra[1]
HiGest660	6	HiGest[2]
AFX960	9	HiGest[2]

1. Genetically-engineered trait developed by FGI International for reduced lignin
2. Traditionally-bred cultivar developed by Alforex (now DLF) for improved quality

Results from Field Trials

Schedule effects yield:

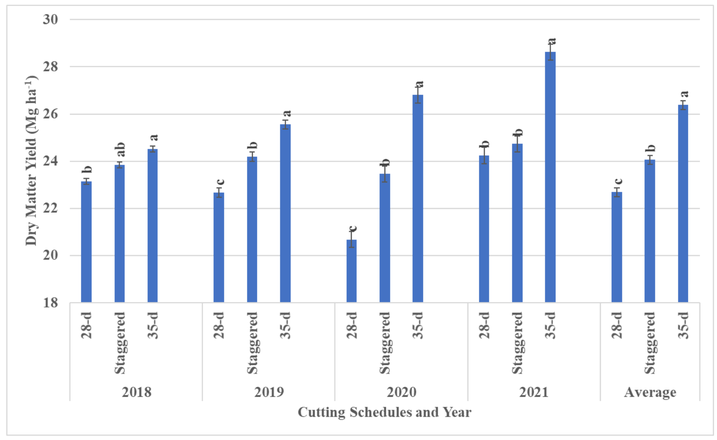


Figure 1. Yields were significantly higher in the late and staggered harvest schedules than the 'normal' schedules. The 'staggered' schedule yields were intermediate, but higher than the 'normal' schedule, although number of harvests were about the same.

Figure 2. Field Studies with three harvest schedules and eight alfalfa cultivars were examined over 4 years in a Mediterranean climate in a replicated split plot design. Shown is UC Davis graduate student Brenda Perez. (photo September, 2019)

Schedule effects quality:

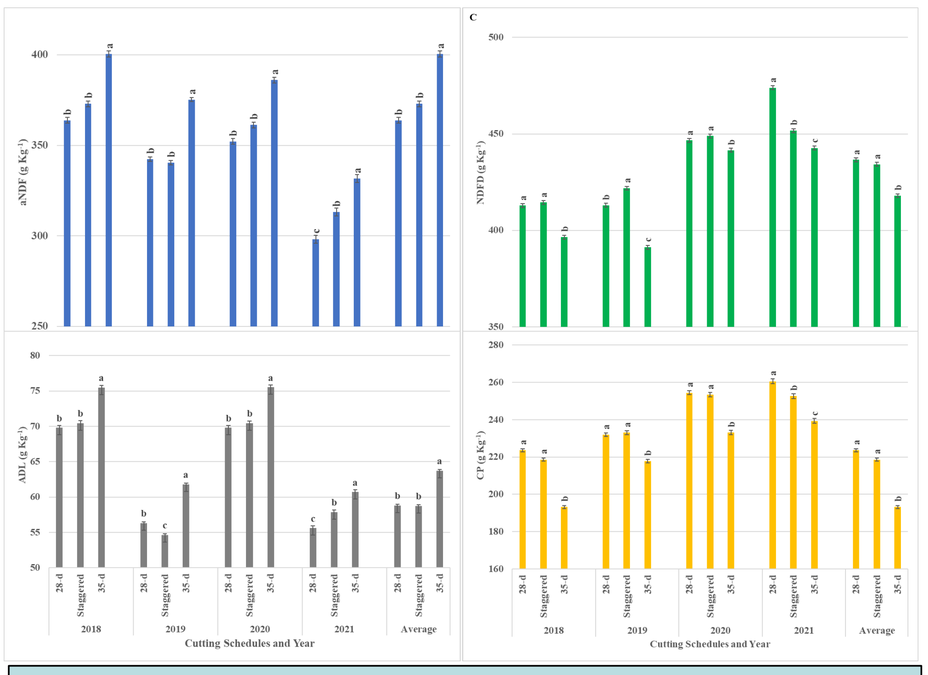
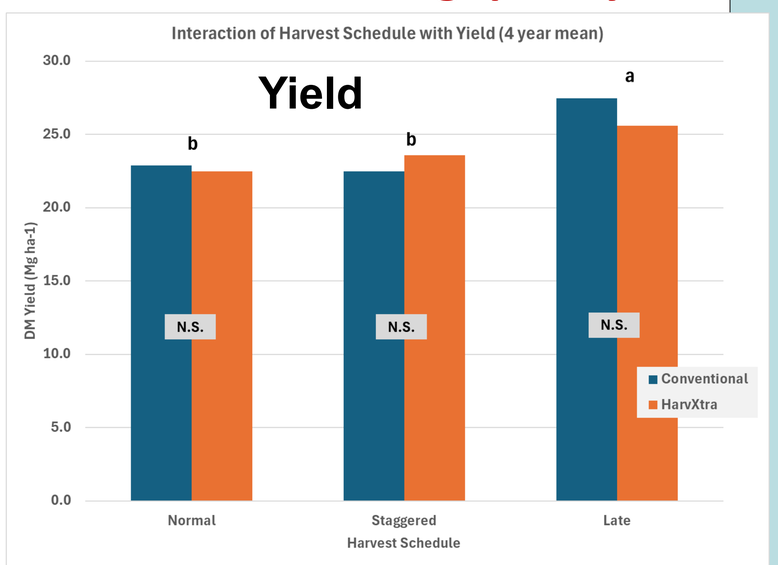


Figure 3. The earliest harvest schedule (normal 28 d) provided the highest quality, while the 'late' schedule yielded the lowest quality and the 'staggered' schedule was similar in average quality to the 'normal' schedule (4 year data).

High quality cultivars enable higher yield from late harvests while maintaining quality:



Cultivar effects quality:

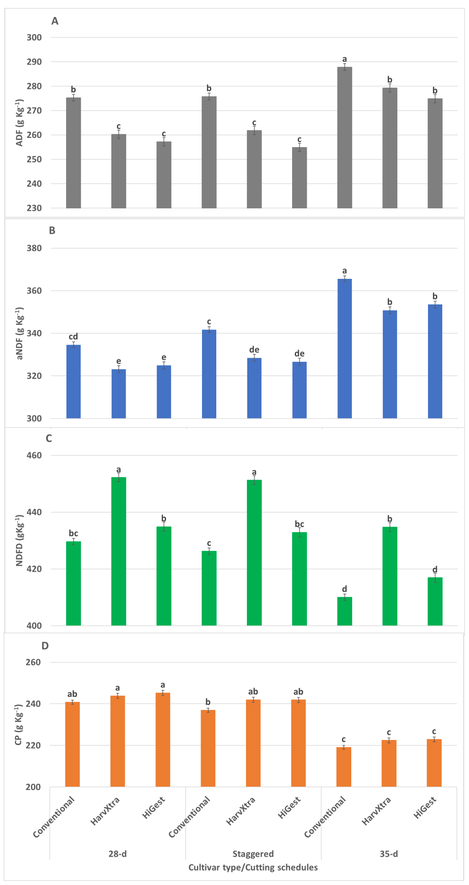


Figure 4. Only HarvXtra lines exhibited higher digestibility (NDFD) than conventional lines, but both HarvXtra and HiGest cultivar types exhibited lower fiber (NDF/ADF) but mostly similar protein (CP) than conventional lines (averaged across harvest schedules and years).

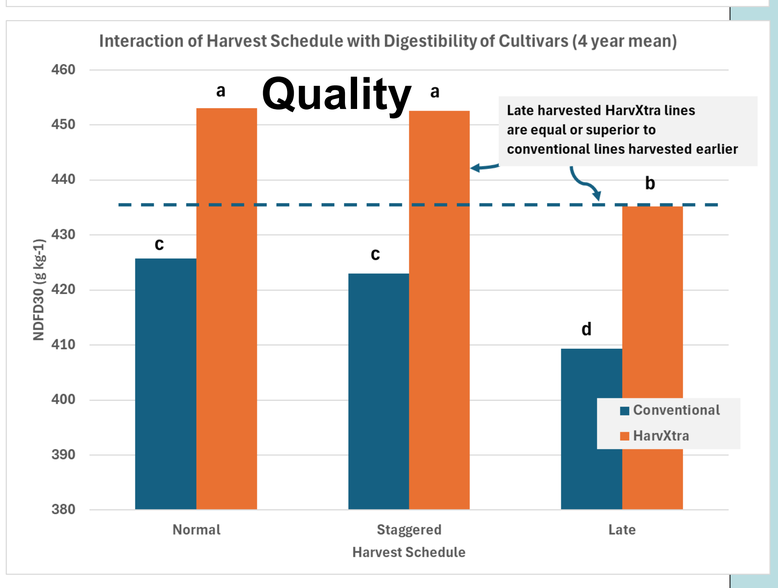


Figure 5. Yield and digestibility (NDFD-30 hr.) of two HarvXtra and two conventional lines (FD 6 and 9), averaged over 4 years. Yields of later-harvested forage were always greater, but digestibility of later-harvested (staggered and late schedules) of HarvXtra lines were superior to NDFD of conventional lines harvested with 'normal' 28-d schedules. While stand density was not affected in this study, numerous studies has shown that later harvests improve stand and persistence.

Schedule Links to Stand Health

Delayed harvests improve yield significantly and reduces quality. However late harvests also improve stand density and longevity. This older dataset illustrate the advantage of late harvest for high yield and better plant density over time, reducing weed intrusion. The introduction of newer, higher digestibility cultivars may allow late harvests, better stands, while also producing high quality.

Effect of Harvest Maturity on Yield, Quality, Stand Health and Weeds (4-year data-Marble, 1974)

Maturity	Days	Yield	ADF	CP	Stand	Weeds
	(Ave)	Mg/ha	%	%	%	%
Pre-Bud	21	16.8	26.3	29.1	29	48
Mid-Bud	25	19.7	29.5	21.3	38	54
10% Bloom	29	22.2	32.2	21.3	45	8
50% Bloom	35	25.5	35.5	16.9	56	2

Links to Sustainability

Longer or staggered harvest schedules improves sustainability by:

- **Improving Stand Density over time**
- **Creating deeper, more vigorous roots to benefit soil health and disease resistance**
- **Improving competition with weeds**
- **Longer stand life & profitability**

The introduction of higher quality varieties enables delayed harvests, higher yields and better stand, while maintaining high-quality forage for sustainable milk production

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