UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Livestock Lines

Stanislaus & San Joaquin Counties
Spring 2025 Volume 30 No. 1

This issue of Livestock Lines is going to focus on irrigated pastures. They have always been a critical part of many operations in the area, and with a new research project I am working on, I wanted to share where we are after one year. But first I want to start with some basics of forage quality and the difference between C3 and C4 plants, so when you get to the article summarizing our year one project, things will make more sense. Feel free to skip ahead to that article if you would like. I am hoping to have a field day in the fall at the Plant Material Center again for anyone who would like to learn more and see the plots themselves.

Understanding Forage Quality: Beyond the Basics

When evaluating forages for livestock, understanding nutritional measurements helps you make informed feeding decisions. Four common metrics—TDN, ADF, NDF, and Net Energy—provide different perspectives on forage value. Let's go over each one and see how the information they provide can help you pick what hay you might want to buy for your animals, or in this case, what forages meet your goals for your irrigated pasture.

Total Digestible Nutrients (TDN)

TDN represents the sum of digestible components in a feed, expressed as a percentage. This traditional measure accounts for digestible proteins, carbohydrates, fats, and more. Higher TDN values indicate better energy content for livestock. For example, high-quality alfalfa might have TDN values of 55-60%, while mature, weathered grass hay might only reach 40-45%.

Acid Detergent Fiber (ADF)

ADF measures the least digestible plant components, primarily cellulose and lignin. As plants mature, ADF ncreases and digestibility decreases. This inverse relationship makes ADF a reliable predictor of forage digestibility - lower ADF percentages indicate more digestible feed. Quality hay typically has ADF values below 35%, while poor-quality forage might exceed 45%.

Neutral Detergent Fiber (NDF)

NDF represents the total cell wall content (hemicellulose, cellulose, and lignin). This measurement correlates with feed intake potential—as NDF increases, animals consume less forage. NDF values vary widely by forage type: legumes naturally have lower NDF than grasses at similar maturity stages. Good-quality alfalfa might have NDF around 40%, while grass hay could range from 55-65%. Since NDF can help give an idea as to how much forage they might consume, it could give you an idea as to how you would have to graze a pasture with this in the mix. If NDF is high (more fiber, less palatable), you might have to increase the stocking rate in the pasture to ensure a more even grazing of all plants, otherwise grass might get "rank" and become even less palatable because now it is in a reproductive stage of maturity instead of vegetative.

Net Energy

Unlike the previous measurements, Net Energy directly estimates the energy available to the animal for different functions. It's typically divided into:

- Net Energy for Maintenance (NEm)
- Net Energy for Gain (NEg)
- Net Energy for Lactation (NEl)

These values, measured in Mcal/lb, account for energy losses during digestion and metabolism. Net Energy provides the most practical measure for balancing rations because it reflects what the animal can

actually use for specific purposes. It can be helpful to look at in order to understand what your animals should be getting from the forage. Since we are focused on irrigated pasture, we are not creating a balanced ration as in a feedlot situation.

Putting it Together

When evaluating forage reports:

- Look at ADF to assess digestibility
- Check NDF to predict intake potential (aka – will it get rank and be a problem in the pasture?)
- Review TDN or Net Energy values for overall energy content

Remember that harvesting stage dramatically affects these values. Early-cut forages generally provide better nutrition than mature plants. For example, early-bloom alfalfa might have 20% ADF and 58% TDN, while full-bloom alfalfa could have 35% ADF and only 50% TDN.

By understanding these measurements, you can not only make the most informed decision on what hay to buy, but for our purposes here, also make an informed decision on what forage species you might plant or add into an already planted irrigated pasture to keep a productive pasture and maintain the critical piece of your operation.

C3 vs. C4 Grasses: Understanding the Fundamental Differences

When managing irrigated pastures, recognizing the distinction between C3 and C4 grasses helps you optimize grazing systems and predict forage productivity throughout the seasons. Maybe even helping keep a productive pasture over a long hot summer.

Photosynthetic Pathways

The names "C3" and "C4" refer to the different biochemical pathways these plants use during photo-synthesis. C3 grasses (like fescue, ryegrass, and orchardgrass – our typical irrigated pasture grasses) produce a 3-carbon compound as their first product of carbon fixation. C4 grasses (such as bermudagrass, dallisgrass, switchgrass, and side-oats) produce a 4-carbon com-pound first. This difference fund-amentally affects how these grasses perform in various environments.

Growth Seasons and Temperature Response

C3 grasses thrive in cooler conditions, making them "cool-season" grasses that grow actively in spring and fall when temperatures range from 65-75ºF. They typically become semi-dormant during hot summer months (our “summer slump” that used to be late summer for a short time). In contrast, C4 "warm-season" grasses reach peak productivity during summer months with temperatures between 85-95ºF but grow slowly or become dormant in cooler conditions.

Water and Nutrient Efficiency

C4 grasses have evolved a more efficient photosynthetic system that allows them to:

- Use water more efficiently (requiring about half the water per unit of growth; helpful when we have to make reductions in irrigation due to pumping or irrigation district restrictions)
- Continue photosynthesizing even when stomata partially close during drought conditions (how they are more efficient – reduce the transpiration rate by partially closing the stomata)
- Maintain productivity in higher temperatures where C3 grasses struggle
- Require less nitrogen to produce the same amount of forage (less input is required for you to add)

Nutritional Differences

C3 grasses generally provide higher nutritional quality with:

- Lower fiber content (lower NDF and ADF values and therefore tend to be more palatable to livestock)
- Higher protein concentrations
- Greater digestibility

However, C4 grasses can produce significantly more total biomass under favorable conditions, often compensating for their somewhat lower nutritional density with greater volume. Would a cheap supplement to compensate mean you can run more animals per acre?

Management Implications

For optimal forage production, consider:

- Utilizing C3 grasses for early spring and late fall grazing
- Relying on C4 grasses during summer months when temperatures exceed 85°F
- In mixed pastures, adjusting grazing pressure seasonally to favor the dominant grass type
- Matching fertilization timing to the active growth periods of your dominant grass species

Understanding the fundamental differences between these grass types and using them to your advantage is the goal of the project I have been working on. What strategies can we develop to keep the irrigated pastures we have productive through the summer months with what has changed from maybe 10 days of 100-degree weather to last year which was 42 days over 100 degrees in Modesto? We have also seen in recent years reductions in irrigation supply due to long-term droughts. Plant Material Centers (PMCs -under the Natural Resource Conservation Service (NRCS)) and Agricultural Research Service centers (ARS- also under the USDA) have been breeding different varieties of grasses to find some that are productive in different environments while improving palatability. Can some of them perform well in California? That's what we want to find out.

Warm Season Irrigated Pasture Grasses for Hotter Summers

When I first started, a "few" years ago, our summers were mainly in the 90's, and it seemed when the temperature would hit 100 or above, it was alway during the fair in July. Bill Van Reit, my predecessor, had information in the files for me about irrigated pastures and "summer slump" as well as about some older research on using warm season perennial grasses (C4s) but the bottom line was the summer slump wasn't "that bad" to compensate for the then C4 grasses that were not as palatable as the C3 species. We still had good water supply and only a week or so where the pasture slowed down. But then we also had more irrigated pastures in the area so chances are you had more options to spread animals around when the production slowed. You had more tools available to you. Fast forward almost 25 years, and we have seen too many years of reduced irrigation due to droughts and last year as mentioned above, we broke records in Modesto and Stockton with 42 and 41 days, respectively, of over 100 degrees. It gets hotter sooner in the year, with graduations in May, last few years being upper 90's and it lasts through September. Luckily our irrigation supply has bounced back after a couple of good winters, but we are always on the edge of another drought. Can we find more palatable C4 grasses that can give us more flexibility in weathering the variability of the summer season? That's what we want to find out.

Already after two years, we have learned some tips to share so you can avoid some of our mistakes. The first being planting too early. Our first year of the project, 2023, we thought planting in late April would be a good time for the C4 grasses, but remember 2023, it was much cooler weather than we have seen in a long time. It was great for us, but not so much for our C4 grasses. Consulting with PMC in New Mexico, we were told it was too cool for the grasses to germinate, so that, and the issue of the seeds being "fluffy" and getting stuck in the planter, lead to basically a complete failure the first year. We learned our lessons, changed the tubes on the planter, cleaned the seeds to remove as much "fluff" as we could, and planted in mid-June 2024. As with the previous year, we irrigated half an inch per week in the beginning, and then an inch a week throughout the summer, overall using about half as much water as is normally applied to irrigated pastures.

Out of the fifteen C4 grasses we planted, we deemed seven to be a "success" for germination. Six species did not germinate, and two were a mixed bag of some decent growth mixed in with a lot of bare ground in each plot. The grasses also took a couple of months to really start to grow and take off, but once they did, there was a lot of tonnage produced. We have gone back out and did some quick checks this spring to see roughly how well they survived their cold, wet California winter, and it looks like five of the seven should be some good options for people to check out. Below is the information we gathered on the seven "successes", tonnage per acre and qualitative information. And note, I messed up and grabbed the forage quality samples all on the same day, but some of the species were already out of vegetative stage and either flowering or had seeds. From above, remember the more mature the plant is, the more fiber and less nutritional value it has. It would have been better if I had been able to grab samples in all vegetative stages over a few weeks time. That will be the plan for this summer.

Phase two of the project will start this summer, planting some of these grasses into irrigated pastures to see how they fair in a "real life" setting instead of the plots where I weeded to reduce any competition. We will also be looking at grazing preferences to see if these grasses are selected at all or ignored for more palatable plants. While I am not expecting the C4 plants to be more palatable than the C3 plants, there might be a time where the benefit of the tonnage produced by the C4s with less water and heat might outweigh the advantages of the C3s.

Date sampled	Species	Tons/ Acre	Vegetative Stage	Crude Protein, %	ADF, %	NDF, %	TDN, %	Net Energy/ Mainten	Net Energy /gain	Net Energy/ Lactati
8/20/24	Alamo Switchgrass	9.70	vegetative	14.5	33.3	64.1	52.9	0.48	0.23	0.48
8/20/24	Cottle County Germplasm Sand Bluestem	3.09	vegetative	14	35.6	61.6	54	0.5	0.25	0.49
8/20/24	Haskell Sideoats Grama	7.99	vegetative	16.1	37.3	69.4	50.8	0.44	0.19	0.45
8/20/24	Loetta Arizona Cottontop	8.92	reproductive	14.6	44.8	71.7	48.9	0.4	0.16	0.43
8/20/24	Niner Sideoats Grama	5.92	flowering	12.4	44.8	71.7	48	0.39	0.14	0.42
8/20/24	Van Horn Green Sprangletop	19.89	vegetative	18	34.9	60.3	57.3	0.57	0.31	0.53
8/20/24	Vaughn Sideoats Grama	10.36	flowering	13.1	44.9	73.5	47.3	0.37	0.13	0.41

Table 1. Successfully germinated C4 grasses and forage production data

Of note on the table above, the five that we believe to be the best options at this point for germination and stand success are Alamo Switchgrass, Haskell Sideoats Grama, Loetta Arizona Cottontop, Niner Sideoats Grama and Vaughn Sideoats Grama. Van Horn Green Sprangletop, interestingly, was one of the ones with patchy stand. Where it did germinate, it produced a lot of forage, estimating close to 20 tons per acres. And it had the highest crude protein, easily enough to meet the demands of your cows at any stage of production as well as growing stockers. The ADF and NDF are all fairly similar when you look at what plants were in a vegetative stage and not flowering or seed set. TDN, again the Sprangletop, has a better TDN percent (like our high-quality alfalfa example) and higher net energy at all three levels of production. It might be one to keep in mind as a possible option.

We will reassess the plants this summer to gauge how well they handled our winters and make it a priority to grab all samples in the vegetative stage for more of a fair comparison across the species. With luck, we will be able to successfully plant some of these species in our partner ranchers' irrigated pastures and assess how well they establish with competition and how palatable they are. Ideally, it would be nice if irrigated pastures are able to remain healthy and productive with the forages we have been using for years, but I fear that we will not go back to our cooler summers and drought has been more of our normal lately. Having some options to keep productivity will be beneficial. Be on the lookout for a fall field day flyer in the future and come check out the plots yourself.

All pictures were taken September 17th, roughly a month after forage production and forage samples sent for quality analysis. Some species are still in vegetative stage of production. From the overview photo, you get a glimpse at the plots where nothing germinated.