UF | IFAS Extension
UNIVERSITY of FLORIDA

23rd Annual

Livestock and Forages Field Day
Presented by:

NORTH FLORIDA
LIVESTOCK AGENTS GROUP

Hosted by: Santa Fe River Ranch

July 14, 2022

UF | IFAS Extension
UNIVERSITY of FLORIDA

Institute of Food and Agricultural Sciences
Northeast Extension District
Northeast Florida Livestcok Agents Working Group

Dear Producer:

Welcome to our Annual Livestock & Forages Field Day, hosted by UF/IFAS Extension Agents representing 13 north Florida Counties! We hope you will enjoy the educational activities planned for you today and that you take away new knowledge, new ideas and new plans to improve your livestock and forage production. Our goal is to help you be more informed and better able to remain sustainable and profitable in all your agricultural endeavors.

I want to take a moment and ask you to help us thank all our industry supporters. Please visit their displays and when the time comes for a new purchase, perhaps one of them may be able to help. I want to also thank you again for supporting our efforts, not just today but throughout the year. Whether you attend this even or any of our local programs, we appreciate your support and look forward to hearing from you about how we can better meet your educational needs.

Two of our biggest supporters that also need to be thanked are:

Alan Hitchcock & his Family for providing us with this beautiful ranch as a venue each year – Thank you Alan and crew.

Farm Credit of Florida for always being there for this event to provide us a great meal.

Thank you all for your generosity and support.

Again, on behalf of all of us in the North Florida Livestock Agents Group (NFLAG), we appreciate you coming, please let us know if we can help in any way. There are plenty of us!

Sincerely,

Dr. Kevin Korus
NFLAG - Chair

UF | IFAS Extension
UNIVERSITY of FLORIDA

The 23rd Annual Livestock & Forages Field Day

Present by the North Florida Livestock Agents Group and Hosted by Santa Fe River Ranch

Agenda

8:00 AM — Vendor Setup

8:30 AM — Registration and Trade Show Opens

9:00 AM—Welcome & Introductions

9:10 AM—Concurrent Sessions (You may attend as many as time permits but please do not move from station to station during presentation.)

Session 1 — 9:10-9:40 AM
Session 2 — 9:40-10:10 AM

Equipment Demos & Sponsorship Break — 10:10-11:00 AM

Session 3 — 11:00-11:30 AM
Session 4 — 11:30-12:00 PM

Concurrent session Topics

- Soil Mapping for Precision Fertility Management
- Variable Rate Fertilizer Application
- Perennial Grass Inter-Cropping and Drone Scouting of Annual Forage Crops
- Heifer Selection and Conditioning
- Electric Fencing and Rotational Grazing

12:00 PM — Lunch (Provided by Farm Credit Florida)

12:30 PM — Keynote Speaker, Andrew P. Griffith, Assoicate Professor – Agriculture and Resource Economics, University of Tennessee

1:30 PM — Adjourn (Exhibit stations and speaker will be available until 2:30 PM for questions and discussion. Sponsorship booths are invited to stay until 2:30 PM as well.)

NORTH FLORIDA
LIVESTOCK AGENTS GROUP

UF | IFAS Extension
UNIVERSITY of FLORIDA

NORTH FLORIDA LIVESTOCK AGENTS GROUP

2022 Livestock and Forage Field Day

1. Registration
2. Intercropping in Perennial Grass Pasture
3. Heifer Selection and Conditioning
4. Soil Mapping for Precision Fertility Management
5. Electric Fencing for Prescribed Grazing
6. Variable Rate Fertilizer Application
7. Covered Barn (Sponsors and Vendors)
8. Equipment Dealer Displays
9. Inside Main Hall (Lunch and Keynote Speaker)

Soil Mapping

The First Step To Increasing Fertilization Efficiency

Caetano (Ky) Sales, Agriculture & Natural Resources Extension Agent, Citrus County
Dr. Kevin Korus, Agriculture & Natural Resources Extension Agent, Alachua County
Dr. Cheryl Mackowiak, Associate Professor at North Florida Research and Education Center

Introduction

Next generation Best Management Practices (BMPs) include soil mapping technologies that rely upon Differential Global Positioning Systems (DGPS) to support site-specfic fertilization or the Right rate of fertilizer applied to the Right place (2 or the 4 R's of fertilizer managment). On-the-go soil mapping technologies have spatial dependence ranges that are much less than the distances used by USDA soil surveys or even most grid sampling techniques. On-the-go mapping technologies are increasingly being used to guide variable applications of irrigation, fertilizer, herbicides, and pesticides in the field.

Figure 1. Veris Unit. Photo credit: Cheryl Mackowiak

Soil Sampling

Soil sampling is the first step in determining the land's fertility throughout a field. Typically, a farmer will collect random soil subsoils across a field, composite those samples into a bucket and then send a subsample of it to a lab for soil fertility analysis. There is no ability to identify good or poor spots in the field. In comparison, for soil mapping, an initial soil grid sampling technique (every 2 to 5 acres) is used, where these samples are sent to a lab for ferility analyses. The results are then used to calibrate the on-the-go mapping results, since on-the-go technologies measure a single soil attribute that is then correlated with the true soil fertility. The classic, soil grid results would be used directly for guiding fertilization management. The on-the-go mapping takes it to the next level.

On-the-go Sensors

Soil electrical conductivity (or apparent EC, ECa) can be correlated with various soil physical and chemical attributes, such as soil texture, moisture, pH, and nutrients. Two of the most common on-the-go mapping technologies to measure ECa are direct contact (Veris Technologies), and electromagnetic induction (Dualem Inc.).

Veris

Veris units are composed of coulter disks on a toolbar. Usually in two pairs, the disks come in contact with the soil to measure the electrical conductivity. One pair of disks sends an electrical current into the soil, and the other reads the voltage coming back from that initial electrical current. The Veris unit collects data from two depths, 1 foot, and 3 feet.

Dual System

With the Dual system, a transmitter coil sends an electromagnetic (EM) field through the soil, and a receiver coil measures variations in the eddy currents that can also be a reflection of soil electrical conductivity. The voltage differences among EM fields is converted into ECa. This non-contact sensor typically collects data from 1 and 3 feet. However, it is sensitive to metallic structures, and vegetation density (Serrano et al., 2014).

Overview

The DualEM method is no-contact, so theoretically the instrument can travel along the soil surface more rapidly than the direct contact (Veris) system. Serrano et al. (2012) found the two technologies correlated with one another. The Dual method was useful when penetrating the soil is difficult, whereas the Veris system tended to have greater stability of readings over time across wide variations in soil moisture. Some Florida fertilizer retailers currently provide soil mapping services and variable rate fertilizer applications. Check with your county agent to learn more about soil mapping service providers in your area!

Figure 2. DUALEM-1S sensor in small open sled.
Photo credit: Dualem Inc.

Further reading

Doolittle, J.A. and E.C. Brevik. 2014. The use of electromagnetic induction techniques in soil studies. Geoderma. 223-225: 33-45.

Serrano, J., S. Shahidian, and J.M. da Silva. 2014. Spatial and temporal patterns of apparent electrical conductivity: DUALEM vs. Veris sensors for monitoring soil properties. Sensors. 2014 (14) 10024-10041.

Sudduth, K.A., N.R. Kitchen, G.A. Bollero, D.G. Bullock, and W.J. Wiebold. 2003. Comparison of electromagnetic induction and direct sensing of soil electrical conductivity. Agronomy Journal. 95:472-482..

Variable Rate Fertilizer

Getting started with precision application technology.

UF | IFAS Extension
UNIVERSITY of FLORIDA

NORTH FLORIDA LIVESTOCK AGENTS GROUP

Alicia Halbritter, Agriculture & Natural Resources Agent, UF/IFAS Extension Baker County

Variable rate technology allows for the application of specific quantities of farming inputs to be applied in specific zones on an operation. Broadcast, or uniform application, of fertilizers can easily waste nutrients by overapplying in some areas and underapplying in others, over time increasing the cost to your operation, not only in monetary cost of the product but also in affected yields.

Soil Mapping

The first step to any fertilizer management plan should be to conduct soil testing. Soil tests help us determine the current state of nutrient levels and pH in the soil, which later dictates what additional nutrients need to be applied. General operational soil testing may only include a few samples but testing to prepare for a change to variable rate application requires a significant number of samples. The more samples submitted, the easier it is to define proper management zones. It is recommended to have at least one soil sample per 2 to 2.5 acres, with specific attention to known problematic or superior areas. This testing method will create a 'grid' to which will be utilized by the computer technology, grids may be combined into overall management zones.

Management Zones

Management zones will be the areas of your operation which have specific treatment requirements. Each zone has a set of similar characteristics, separating it from the zones around it. Management areas can be defined using the grid soil sampling, topography, soil maps, aerial imagery, and most importantly, historical knowledge of the field. The farmers knowledge of the fields performance, flooding zones, and previous cropping methods can influence which areas will be defined together as a management zone. In the initial years of implementation, it may be useful to have fewer management zones to improve adaption of the precision agriculture strategy.

Equipment

Equipment needs will vary based on what the operation currently has. Overall, a farmer needs a tractor capable of utilizing an in-cab computer with a field zone application map, fertilizing equipment capable of changing rates during operation, and a global positioning system receiver. Some equipment may be available with limited options that require less advanced equipment. Costs of this equipment can vary significantly depending on each operation and their needs.

Benefits & Considerations

Variable rate technology has the ability to advance your operations efficiency and profitability. Improving nutrient efficiency across a field can improve yields while also potentially reducing overall fertilizer needs. Less input cost provides opportunity for higher profit margins. Once variable rate equipment has been established it can be utilized for fertilizer, seeding, and spraying. However, the initial set up can be expensive, including soil testing costs, therefore a careful economic analysis should be completed to determine potential return on investment.

Intercropping in Perennial Grass Pastures

Tyler Pittman, Ph.d., Agriculture & Natural Resources Agent, UF/IFAS Extension Gilchrist County

Planting annual forage species such as small grains and legumes into perennial grass pastures can be a great way to supplement your livestock's summer and winter nutrition program. Intercropping can also help save fertilizer and money through the reduced need for other supplemental feeds. In many instances the success of these intercropping efforts depends on preparation, practices used and management.

Variety and Blend Selection Considerations

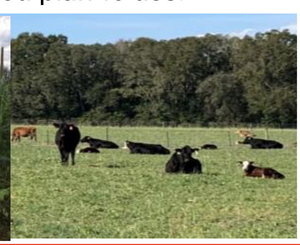
There are a few important characteristics to consider when selecting varieties and/or blends of varieties that will impact the success of your annual forages.

Site Characteristics - Depending on things like soil type, irrigation, and perennial grass species present your variety selection can make a huge difference in forage production. For example, dry sandy soils with no irrigation would dictate selection of drought hardy species while the availability of irrigation or the presence of heavier soils will allow you more flexibility in variety selection. Also planting annuals into established Bahia grass pastures may dictate you use a fast germinating and growing variety compared to planting into Bermuda grass pastures.

Grazing Strategy – How you plan to graze your annual forages should be a major consideration in selecting varieties and blends.

Grazing Strategy Continued – Your grazing strategy takes into account your stocking rate, mob grazing or continual grazing, duration of grazing period, and your overall grazing scheme. Annuals that plan to be grazed over the entire summer or winter and/or continually grazed would dictate variety with good regrowth potential while annuals planted for calving season that will be flash grazed might not require such high regrowth potential. These grazing strategies also dictate how many species you should include in your annual grazing blend. A general rule of thumb is that the more species in the blend the more robust that blend is to grazing and environmental conditions meaning you are likely to obtain greater nutrition, grazing duration and cost savings from blends like this.

Planting Methods – The final important consideration is planting method. Whether you use a no-till drill, conventional drill, or broadcasting this will dictate what varieties you plant and how many species you include in your blend. Will you do any land preparation such as applying herbicides ahead of planting, aerating and tillage, or apply fertilizers at start. All of these things can dictate which species and varieties you including in your blend based on how the characteristics of those varieties and species fit the practices you plan to use.



Varieties and Blends

Summer Annuals – An ideal summer annual blend is usually a combination of grasses and grass hybrids and legumes. Some of the most common grass/grain varieties are sorghum-sudan grass, sudan grass, forage sorghum, pearl millet, and crab grass. Legumes used are typically things like sun hemp, vetch, and cow peas. Many blends also include forage turnips and sunflower. Although summer blends can have very high nutritional value caution should be used when grazing them in hot and dry conditions because of the build up of nitrates that can lead to nitrate toxicity.

Winter Annuals – An ideal winter annual blend will consist of 2-3 small grains like oats, cereal rye or triticale of which numerous varieties exist for various situations. Consult the UF/IFAS Small Grain Program for yearly forage variety recommendations. They also include 1-2 legume species such as clovers and peas of which varieties exist for a wide range of environmental conditions. Finally including 1-2 species of brassicas like mustard or daikon radish provide an additional source of forage protein and soil health benefits. A blend like this should provide you season long grazing while requiring minimal inputs and creating soil health improvements.

Planting Methods

Land Preparation – Planting into perennial pastures can be difficult because you are planting directly into a well-established competing crop making how we prepare these pastures very important. When planting winter annuals grazing off perennial pasture low and waiting until dormancy is the simplest approach. However, this could lead to difficulty in hitting the ideal timing for planting annuals in the fall/winter. Many producers may utilize other equipment such as aerator or disk to lightly disturbed the perennial grass to slightly reduce competition with the winter annuals they are planting. Another option is to apply a very low rate of herbicide to stunt or bring on early dormancy in perennial grass that allows for better germination and growths in winter annuals.

This isn't an option for summer annuals as we are also relying on our perennial grasses as a forage at this time.

Planting Equipment - Also using equipment like a no-till drill or a plant-o-vater can allow you to plant into these perennially pastures with more success and less preparation. Essentially these pieces of equipment create a very small prepared seed bed to plant into compared to a conventional drill or broadcasting which rely on the seed bed present when planted. For summer annuals using a piece of a equipment like a no-till drill or a plant-o-vater are essential to have a successful summer annual forage. Conventional drills and broadcasting do not give the annuals an advantage over the perennial grasses like the no-till drill or plant-o-vater. Choosing the right combination of land preparation techniques and equipment can make a substantial difference in the performance of annual forages.

Fertilization and Grazing Management

For summer annuals apply 30 lbs. of N/acre and 50% of the soil test recommended rate of Phosphorus and Potassium. Apply 50 lbs. of N and the remaining Phosphorus and Potassium. If intercropping in perennial grass pasture during the growing season the recommended fertilization rates for that forage should be sufficient for summer annuals. See EDIS: Fertilizing and Liming Forage Crops.

For winter annuals fertilization is usually based on soil test recommend rates for phosphorus and potassium. With the inclusion of legumes nitrogen fertilizer is typically not recommended. However, many producer apply 40 lbs. of nitrogen at planting to provide nitrogen until legume nitrogen fixation has started. See EDIS: Winer Forage Legume Guide.

Electric Fence

Equipment to get started with this powerful tool in grazing management

Caetano (Ky) Sales, Agriculture & Natural Resources Extension Agent, Citrus County
Anna P. Tomlinson, Agriculture & Natural Resources Extension Agent, Columbia County

Rotational grazing with Electric Fence

Grazing management is crucial in maintaining a healthy herd and, more importantly, a healthy pasture. One of the best practices is rotating animals through pastures, allowing forage crops to regrow, maintaining yield and nutritive value, and ensuring the stand's longevity.
The concept of rotational grazing is moving animals through pastures based on the pasture's ability to supply nutrients and the animals' nutritional requirements. Increased grazing intensity occurs as large pastures are sectioned into smaller areas and animals graze. With the high costs of building permanent fencing, an option is to use temporary electric fencing. The flexibility of quickly and easily moving a fence or creating new paddocks makes temporary electric fencing a powerful tool for producers in managing their animal's ability to graze. The following information covers the basic equipment required for setting up an electric fence on your property.

Equipment

Wire - Temporary electric fencing is built on one or two strands of electrified wire. There are two types of wire used polytape and polywire. They are composed of polyethylene or polypropylene fibers braided with metal filaments, which carry the shock. The fibers are crucial for the wire's strength and its visibility; very important, an animal won't respect the wire if it cannot see it. Polytape is best used when animal control is inadequate, as it has better visibility. Producers mainly use Polywire to subdivide pastures into paddocks, as polywire is easier to reel and move than polytape. Polywire and polytape come in different numbers of conductive strands, three, six, or nine. The amount of conductive strands influences how much voltage the wire conducts. For the purpose of subdividing short distances in pastures, the six-strand with stainless steel conductors is enough to get the job done.
It is essential to have a good reel for your wires. Proper temporary fence reels are made to withstand harsh weather conditions, hold more than one spool, will prevent from breaking the metal filaments in the wire, and prevent the wire from getting tangled.

Posts - Several materials are used in temporary fencing posts—metal, plastic, and fiberglass. Plastic posts are recommended for fences that are moved regularly due to the ease of installation and removal. Plastic posts have treads to step into the ground and pre-molded loops allowing for a range of wire spacings.

Fiberglass posts are recommended when the fence will not be moved regularly. The wire is held in place by plastic insulators or wire clips that slide on the rods. Fiberglass posts take more time to install than plastic posts but are more affordable. Metal posts, such as rebar and t-posts, last the longest among fencing posts. Plastic insulators hold the wire in place. However, they are labor-intensive when installing and removing to change paddock size.

UF | IFAS Extension
UNIVERSITY of FLORIDA

Energizers - Energizers are measured in volts. However, the voltage level only determines if the shock will or not be sent to the animal. Shock intensity is measured in joules, which is the combination of voltage, amperage, and shock duration. The effectiveness of the shock intensity will depend if the voltage is sufficient to deliver a shock.

Good fence energizers are low impedance and provide from 6,000 to 8,000 volts. A minimum of 5,000 volts are necessary to control large animals like cattle and horses. High-impedance energizers "leak" current easily, meaning that any grass or weed that comes in contact with the wire will drain power and can cause a fire with the heat buildup.

Power sources for energizers can be battery-operated, solar energy, or AC-powered, which produce higher amounts of joules. Battery and solar-operated energizers work very well and are recommended when a 120-volt power source is not available or in close proximity.

Grounding

Grounding is the main issue of electric fences not working correctly. An electric fence will only shock an animal if the circuit is complete. Proper grounding is necessary to complete the circuit and make the fence electrified. The circuit in temporary electric fences is composed of an electrified wire and a grounding rod; the energizer provides the voltage that travels from the wire to the animal, to the soil, down the grounding rod, and back up to the energizer. The animal does not feel a shock from the wire without proper grounding, resulting in animals that will not respect the wire.
The rule of thumb for reliable grounding is at least three 6-foot galvanized ground rods. Rods should be spaced from one another at a minimum of 10 feet and set 5 ½ feet deep.

Overview

Electric fence is a great tool that can be added to any grazing management scheme. Understanding how electricity works through the fence and how animals will interact with the fence is the first step. Remember when introducing animals for the first time to the electric fence, make sure it is "hot," very hot. Respect for the fence is learned the first time it is touched, and in time it will become more of a psychological barrier than an actual physical barrier. Through trial and error, this tool can adapt to any livestock operation and be used in a range of daily management tasks.

NORTH FLORIDA LIVESTOCK AGENTS GROUP

Heifer Selection & Conditioning

Replacement Heifer Development

Lizzie Whitehead, Livestock and Natural Resource Agent Bradford County Extension,
Dr. Nicolas DiLorenzo, Professor at North Florida Research and Education Center,
Dr. Cindy Sanders, Livestock Agent & County Extension Director Alachua County Extension

Introduction

Depending on which calving season you have, cattleman must make decisions on which heifer calves they want to keep or buy for their herd. Usually, 10-20% of your herd will need to be replaced with heifers each year. It is extremely important to apply adequate selection pressure to prospective herd replacements at weaning and after weaning. Developing these heifers to become productive females in your cow herd can be a tremendous investment in a cow-calf operation. The following are some guidelines that should be used when selecting your replacement heifers.

Record Keeping

An individual record should be kept on each cow in your herd. Whether you right it down on a note pad or keep it in your cell phone, knowing when this cow has calved, birth weight, and making sure the calf is growing properly is essential information. Keeping records on the following information will help you select the heifers that you want to keep out of your high performing cows:

1. Calving Percentage
2. Cow Performance (Body condition, number of calves, rebreeding, etc.)
3. Weaning Weights
4. Quality of Calves at Weaning (are all the calves the same size and uniform in weight)

Longevity is Important

It is important to keep heifers that are being selected from the cows that have consistently produced a heavy weight and high-quality calf every year. Keep notes on which cows have a 12-13 month calving interval each year. If it is possible look at birth dates and select those heifers that were born in the beginning of your calving season. Research shows that these heifers tend to reach puberty at an earlier age. This means that these heifers should start their estrus cycle earlier and get bred earlier, then those that calved at the end of your breeding season. Select high quality heifers at weaning time:

1. Heifers from a High Milking Dam
2. Disposition
3. Visual Appraisal
4. Adequate Growth

Heifer Average Daily Gain

Heifers should be gaining 1.5- 2.25 lbs/d to reach 65% of their mature weight when it is time to start breeding them at 15 months of age so they can calve at 2 years old. Monitor your heifers by viewing their body condition scores to make sure they are not losing or gaining to much weight. Depending on the breed of heifer, weights will vary and age of maturity will vary. Heifers that have failed to develop and gain the appropriate amount of weight should be culled. For Example:

-Mature Weight: 1200 lbs
-Weight at Breeding: 780 lbs

UF | IFAS Extension
UNIVERSITY of FLORIDA

Conditioning

In order to achieve a target body weight for a cycling heifer at breeding, some challenges need to be overcome. The first challenge is making sure your heifers are achieving an ideal average daily weight gain (ADG) to avoid over and under conditioning. Here are a few tips on how to over come these challenges:

1. High enough protein concentration to support muscle growth
2. Ideal heifer development Crude Protein percentage in their diet 13-14% and TDN of 55%
3. Make sure energy content is enough to reach the target ADG
4. Another option: Winter annual grasses such as oats, triticale, rye or a combination of those
5. Make a plan and have a good back up plan if the forage production is not optimal

Reproduction Potential

When your heifers are reaching breeding age, keep a record of who has come into heat and who hasn't. Depending on the size of your operation, there are a few different options to check and see if your heifers are cycling. If they are not cycling, you can set them up with an estrus synchronization protocol to get them to reach puberty. Listed below are some different ways that you can document if your heifers are ready for breeding season :

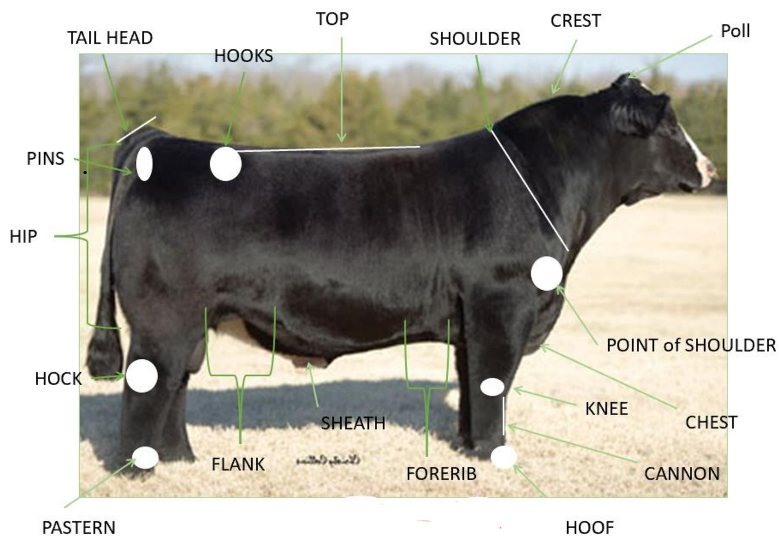
1. Take record to see who has come into standing heat
2. Use the Reproductive Tract Score (RTS) method by a large animal practitioner with palpation and/or ultrasound technology
3. Obtain pelvic measurements two to three weeks before the breeding season
4. Palpating for ovarian development

NORTH FLORIDA
LIVESTOCK AGENTS GROUP

Selection Based on Visual Appraisal

When selecting heifers visually, the following criteria should be considered:

- Volume & Capacity
  - Spring of rib
  - Depth of body
  - Natural thickness & shape down the top
  - Width & depth to stifle
  - Width in her pin set
- Frame & Growth
  - Moderate frame
  - Length of body
  - High performance
- Design & Structure
  - Stands square on front & rear legs
  - Heavy boned
  - Walks with flexibility in their pasterns
  - Level from her hooks to her pins
  - Moves with flexibility in her hock
  - Correct angle in her shoulder
- Femininity
  - Feminine: Want your females to look like females
  - Smooth shoulder
  - Long fronted
  - Check her teats and make sure they look uniformed
- Balance
  - Level down her top
  - Want her forerib to be level with her flank
  - Deep flank



Beef Economic Climate and Outlook

Andrew P. Griffith
Associate Professor in Extension
Livestock Economist

UTEXTENSION INSTITUTE OF AGRICULTURE THE UNIVERSITY OF TENNESSEE

1

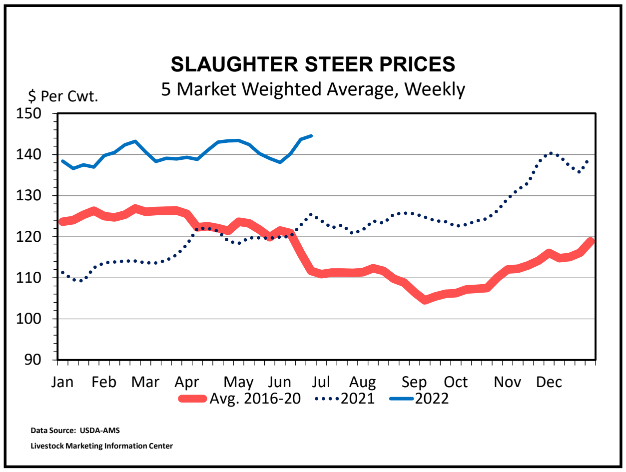
Summary

- Cattle prices are volatile/optimistic
- Drought influencing heifer retention and slaughter rates
- Margin operators have opportunities to hedge for 2022 and may still be a good decision
- International market is strong, but political unrest leading to volatility

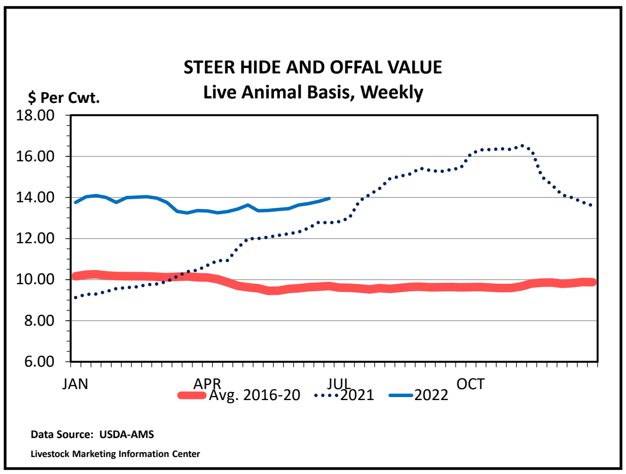
2

Current Cattle Prices

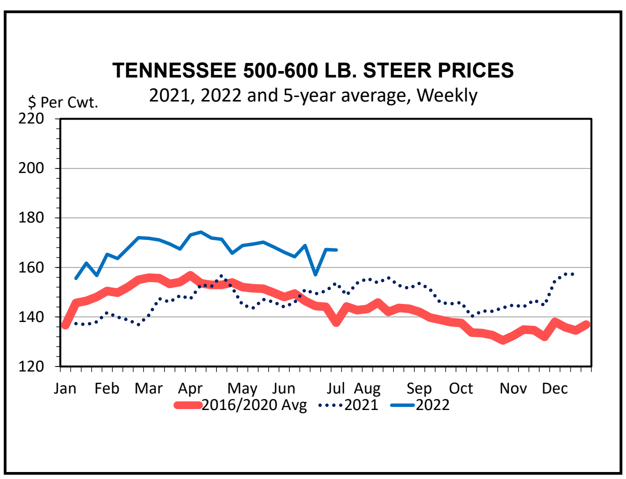
3


SLAUGHTER STEER PRICES
5 Market Weighted Average, Weekly
$ Per Cwt.
150
140
130
120
110
100
90
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Avg. 2016-20
2021
2022
Data Source: USDA-AMS
Livestock Marketing Information Center

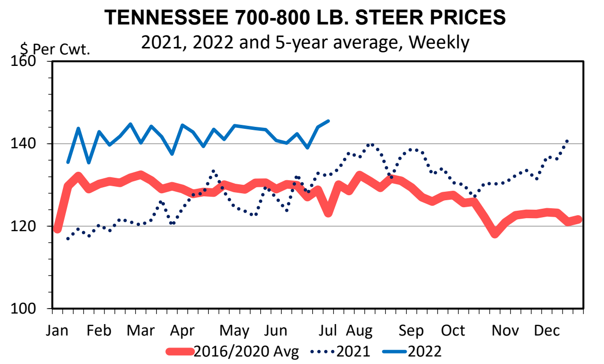
4


STEER HIDE AND OFFAL VALUE
Live Animal Basis, Weekly
$ Per Cwt.
18.00
16.00
14.00
12.00
10.00
8.00
6.00
JAN APR JUL OCT
Avg. 2016-20
2021
2022
Data Source: USDA-AMS
Livestock Marketing Information Center

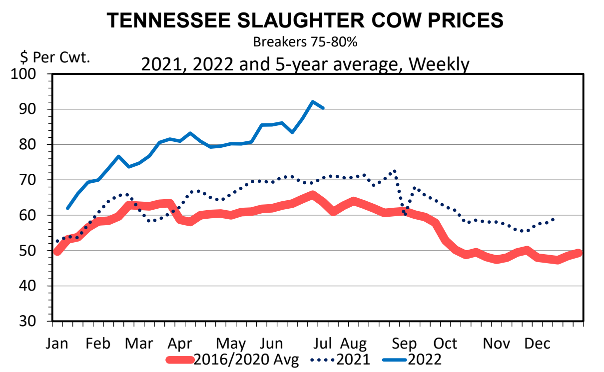
5


TENNESSEE 500-600 LB. STEER PRICES
2021, 2022 and 5-year average, Weekly
$ Per Cwt.
220
200
180
160
140
120
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2016/2020 Avg
2021
2022

6



7



8

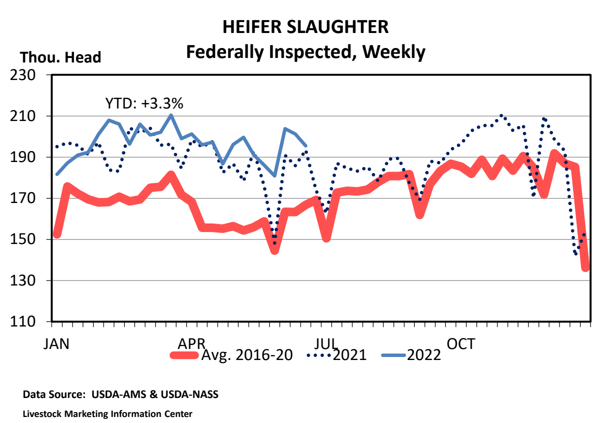
Slaughter and Meat Production

9

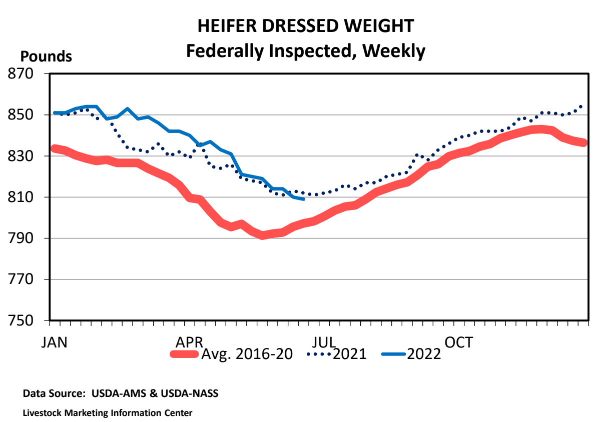
2022 Slaughter YTD

- Heifer: up 3.3%
- Steer: down 1.8%
- Beef cows: up 14.3%

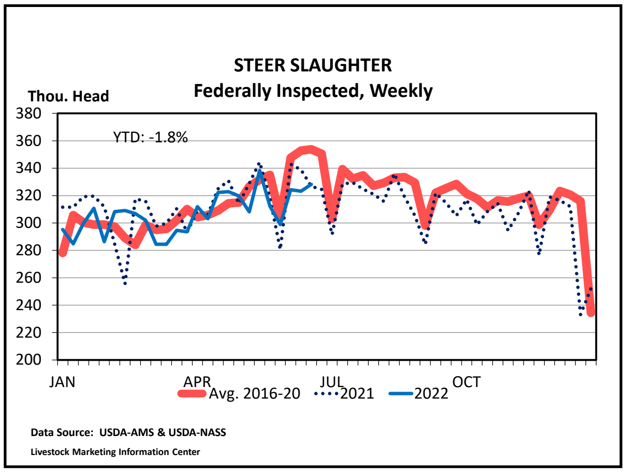
10



11

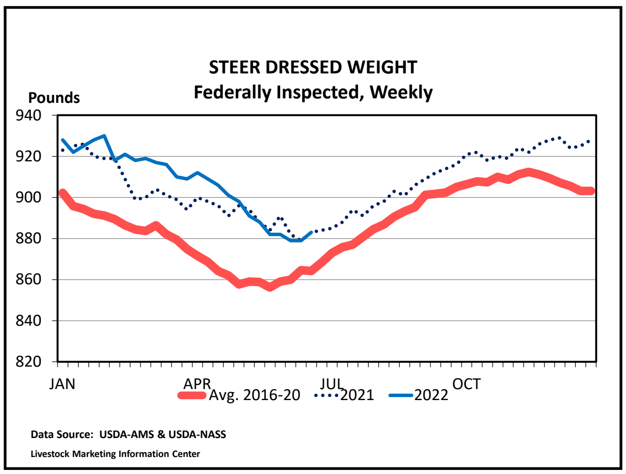


12



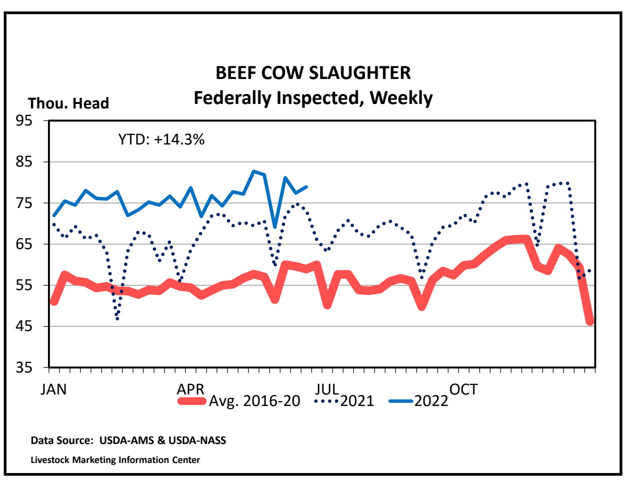
STEER SLAUGHTER
Federally Inspected, Weekly
Thou. Head
YTD: -1.8%
380
360
340
320
300
280
260
240
220
200
JAN
APR
JUL
OCT
Avg. 2016-20
2021
2022
Data Source: USDA-AMS & USDA-NASS
Livestock Marketing Information Center

13



STEER DRESSED WEIGHT
Federally Inspected, Weekly
Pounds
940
920
900
880
860
840
820
JAN
APR
JUL
OCT
Avg. 2016-20
2021
2022
Data Source: USDA-AMS & USDA-NASS
Livestock Marketing Information Center

14



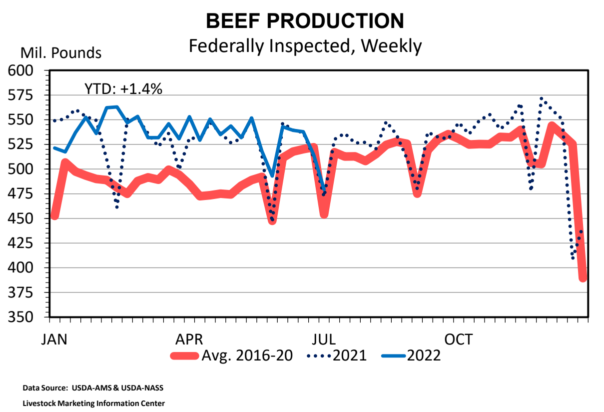
BEEF COW SLAUGHTER
Federally Inspected, Weekly
Thou. Head
YTD: +14.3%
95
85
75
65
55
45
35
JAN
APR
JUL
OCT
Avg. 2016-20
2021
2022
Data Source: USDA-AMS & USDA-NASS
Livestock Marketing Information Center

15

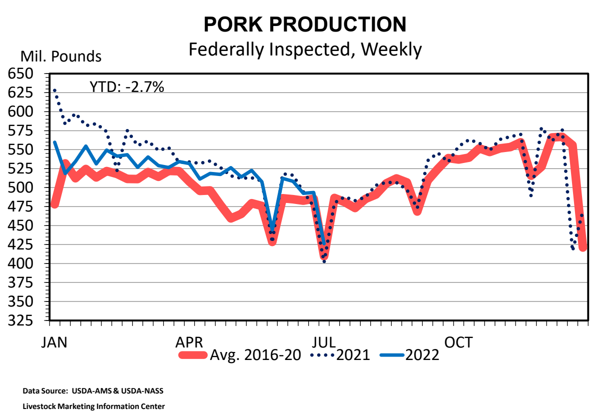
2022 Meat Production YTD

- Beef production: up 1.4%
- Pork production: down 2.7%
- Broiler production: up 1.1%

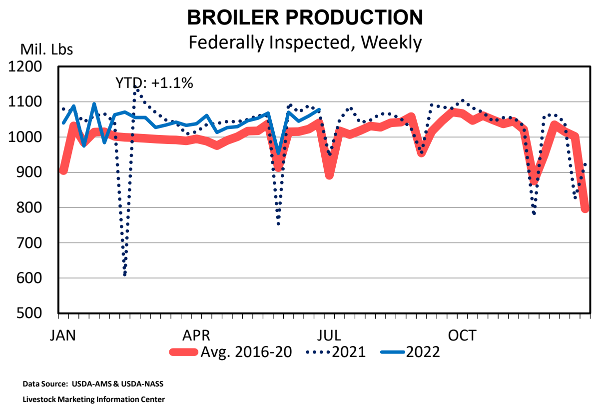
16



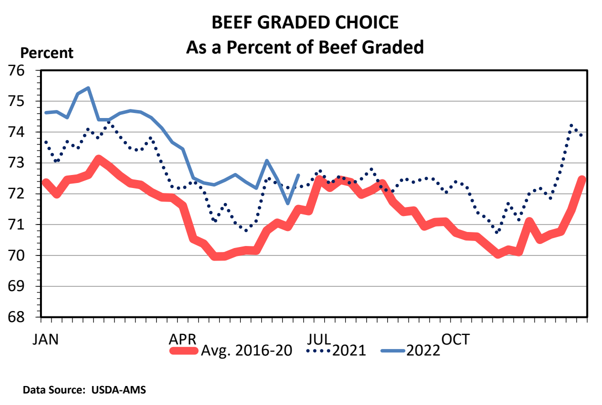
17



18



19



20

Implications

- Plenty of meat available
- Must export beef and pork products
- Domestic beef demand is still pretty good

21

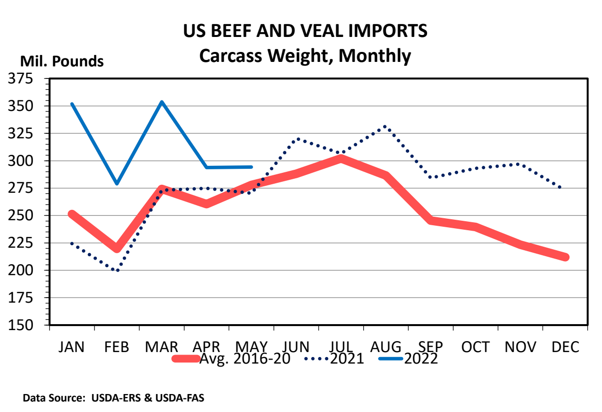
International Trade

22

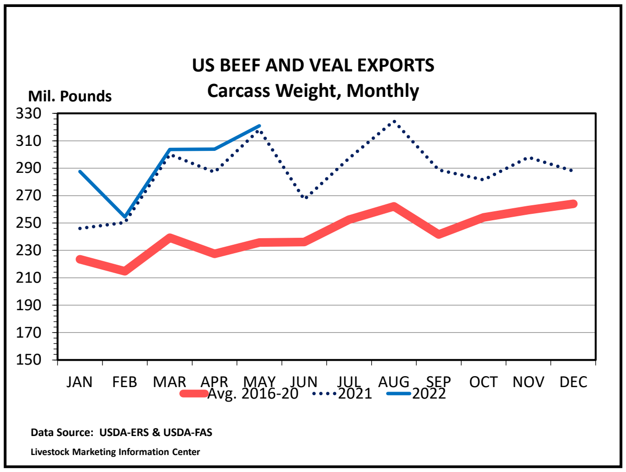
A Lot is Happening

- China is always a loose cannon
- Japan and South Korea still strong markets
- Brazilian imports remain strong

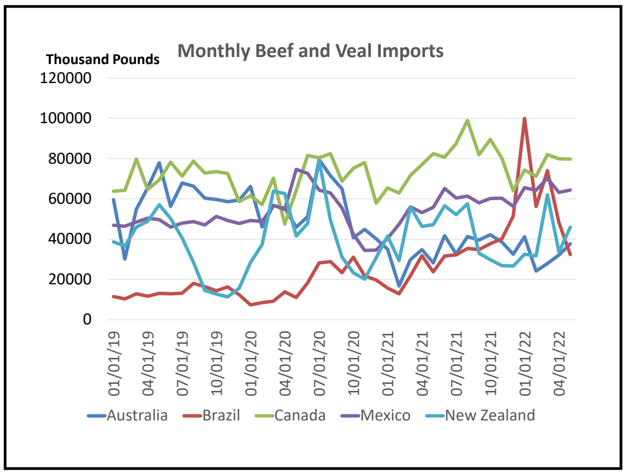
23



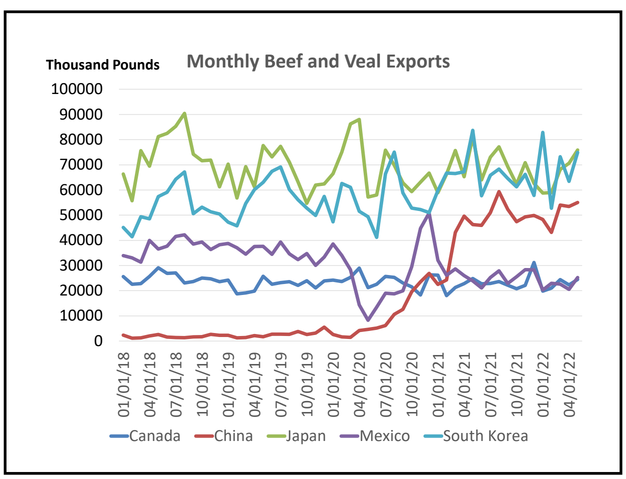
24


US BEEF AND VEAL EXPORTS
Carcass Weight, Monthly
Mil. Pounds
330
310
290
270
250
230
210
190
170
150
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Avg. 2016-20
2021
2022
Data Source: USDA-ERS & USDA-FAS
Livestock Marketing Information Center

25


Monthly Beef and Veal Imports
Thousand Pounds
120000
100000
80000
60000
40000
20000
0
01/01/19
04/01/19
07/01/19
10/01/19
01/01/20
04/01/20
07/01/20
10/01/20
01/01/21
04/01/21
07/01/21
10/01/21
01/01/22
04/01/22
Australia
Brazil
Canada
Mexico
New Zealand

26


Monthly Beef and Veal Exports
Thousand Pounds
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
01/01/18
04/01/18
07/01/18
10/01/18
01/01/19
04/01/19
07/01/19
10/01/19
01/01/20
04/01/20
07/01/20
10/01/20
01/01/21
04/01/21
07/01/21
10/01/21
01/01/22
04/01/22
Canada
China
Japan
Mexico
South Korea

27

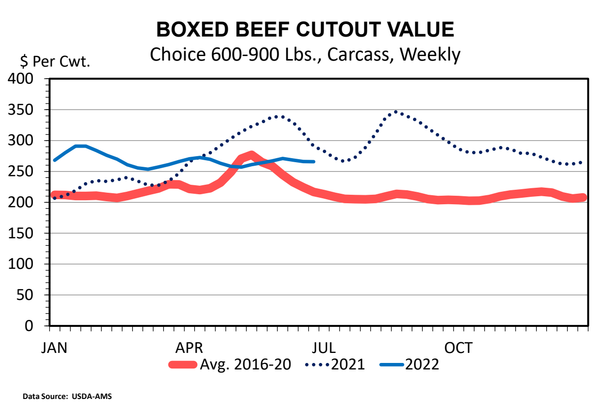
Implications

- Imports of inexpensive lean manufacturing beef fairly strong
- Changes to Japan agreement reduce likelihood of hitting safeguard limit
- China is demanding meat (pork, beef)

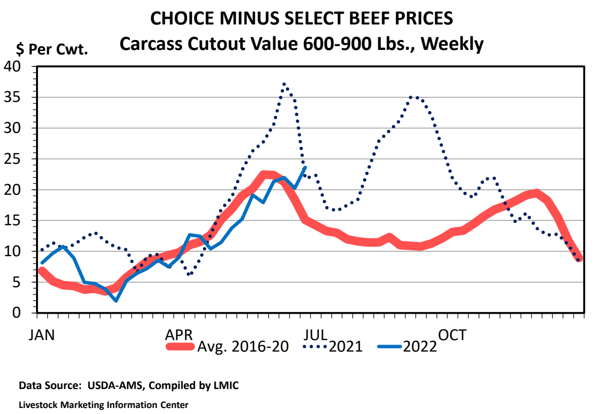
28

Meat Prices

29



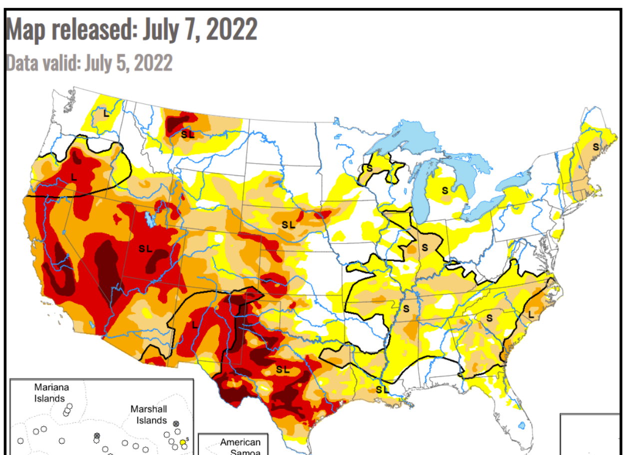
30



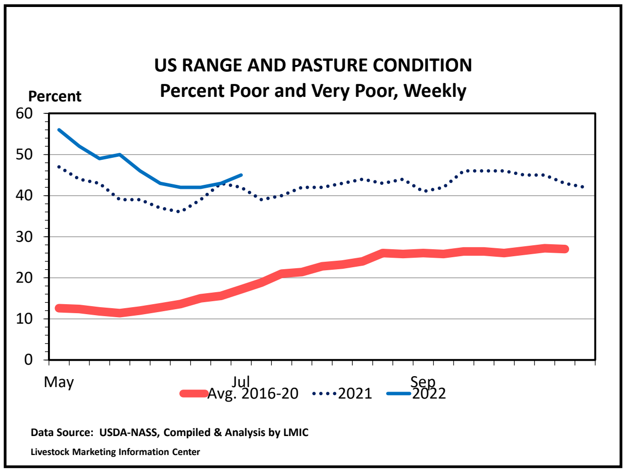
31

Feed Situation

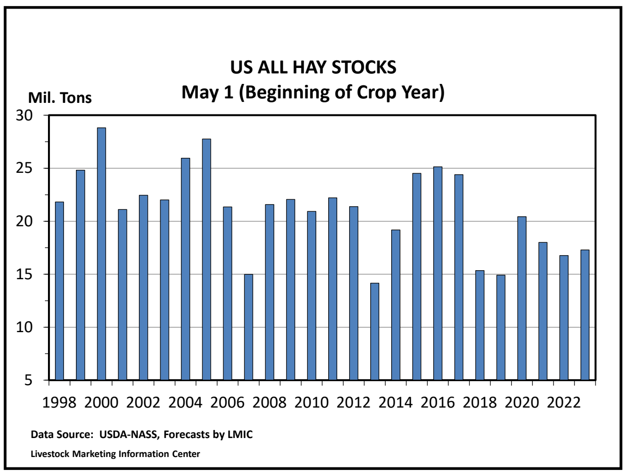
32



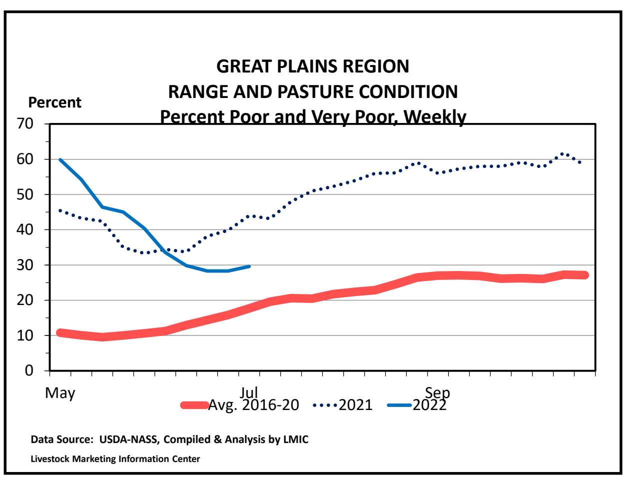
33


US RANGE AND PASTURE CONDITION
Percent Poor and Very Poor, Weekly
Percent
60
50
40
30
20
10
0
May
Jul
Sep
Avg. 2016-20
2021
2022
Data Source: USDA-NASS, Compiled & Analysis by LMIC
Livestock Marketing Information Center

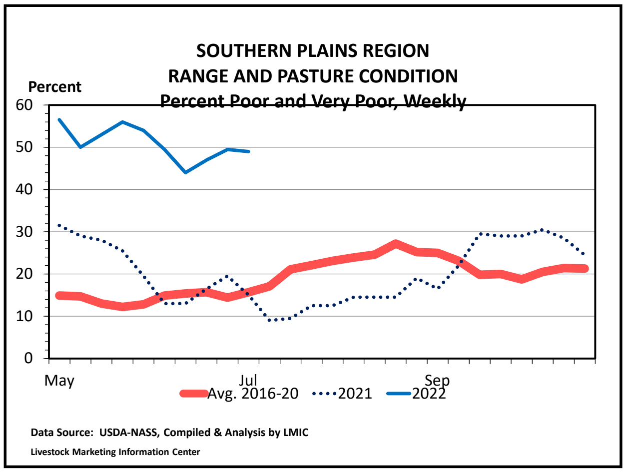
34


US ALL HAY STOCKS
May 1 (Beginning of Crop Year)
Mil. Tons
30
25
20
15
10
5
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Data Source: USDA-NASS, Forecasts by LMIC
Livestock Marketing Information Center

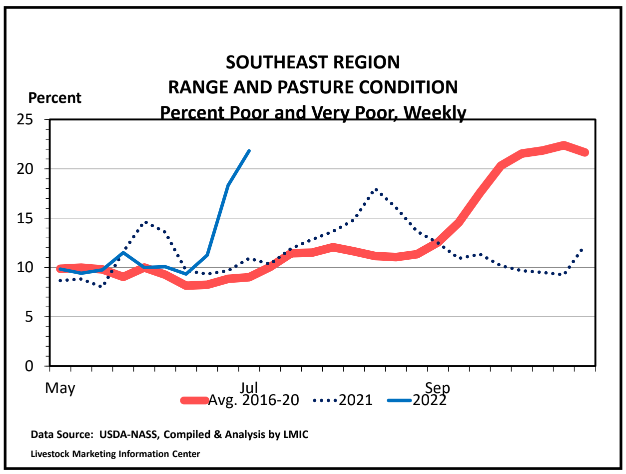
35


GREAT PLAINS REGION
RANGE AND PASTURE CONDITION
Percent Poor and Very Poor, Weekly
Percent
70
60
50
40
30
20
10
0
May
Jul
Sep
Avg. 2016-20
2021
2022
Data Source: USDA-NASS, Compiled & Analysis by LMIC
Livestock Marketing Information Center

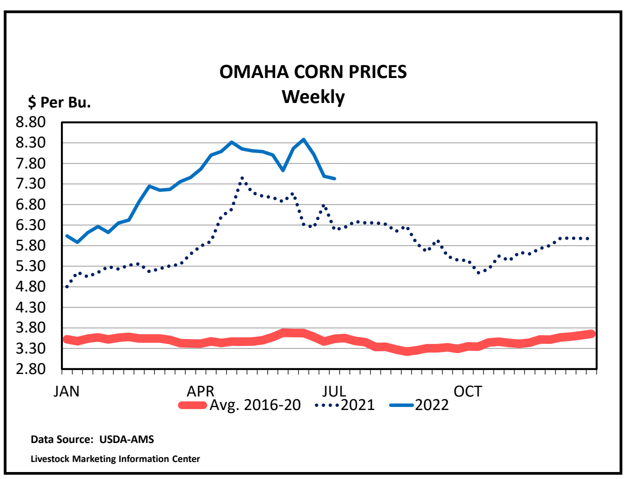
36


SOUTHERN PLAINS REGION
RANGE AND PASTURE CONDITION
Percent Poor and Very Poor, Weekly
Percent
60
50
40
30
20
10
0
May
Jul
Sep
Avg. 2016-20
2021
2022
Data Source: USDA-NASS, Compiled & Analysis by LMIC
Livestock Marketing Information Center

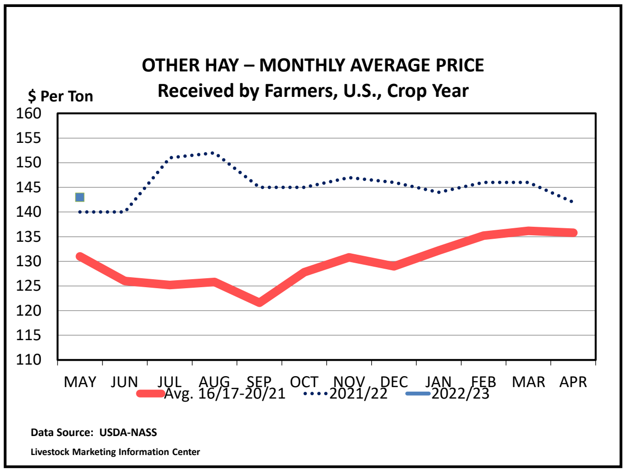
37


SOUTHEAST REGION
RANGE AND PASTURE CONDITION
Percent Poor and Very Poor, Weekly
Percent
25
20
15
10
5
0
May
Jul
Sep
Avg. 2016-20
2021
2022
Data Source: USDA-NASS, Compiled & Analysis by LMIC
Livestock Marketing Information Center

38


OMAHA CORN PRICES
Weekly
$ Per Bu.
8.80
8.30
7.80
7.30
6.80
6.30
5.80
5.30
4.80
4.30
3.80
3.30
2.80
JAN
APR
JUL
OCT
Avg. 2016-20
2021
2022
Data Source: USDA-AMS
Livestock Marketing Information Center

39



40

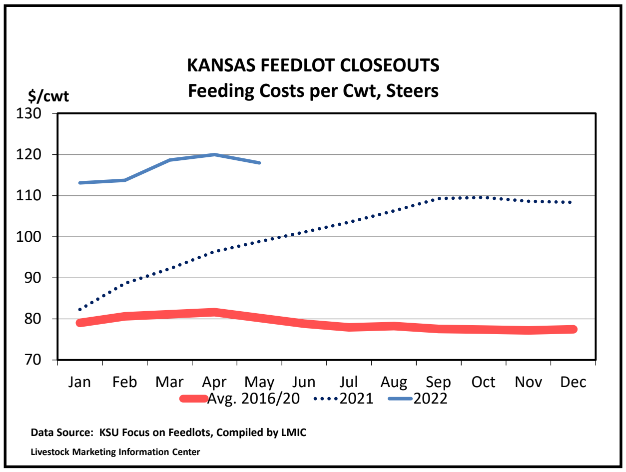
Implications

- Corn prices are putting pressure on feeder cattle prices
- Hay and forage have regional variability

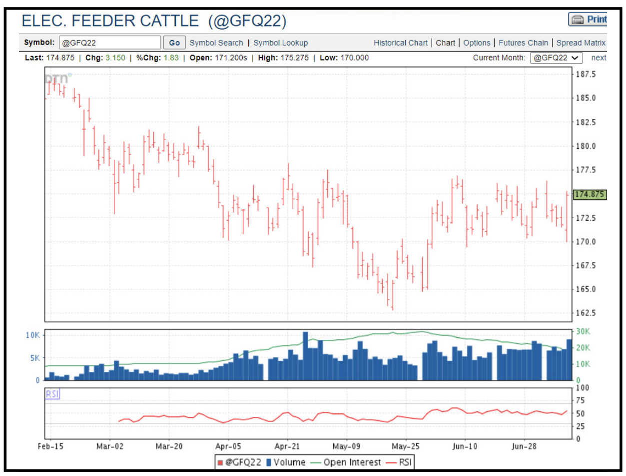
41

The Feedlot

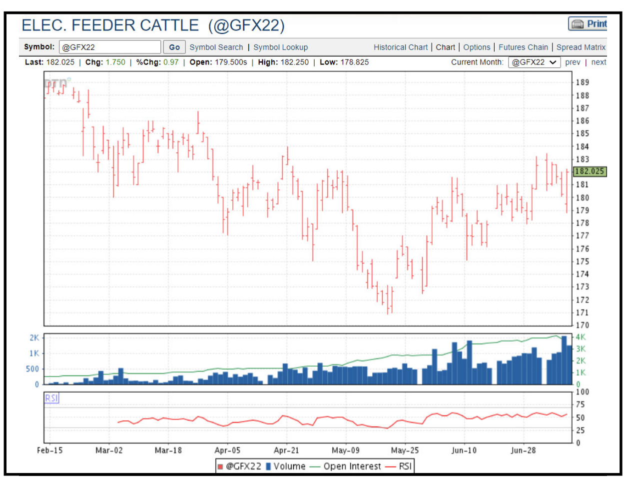
42


KANSAS FEEDLOT CLOSEOUTS
Feeding Costs per Cwt, Steers
$/cwt
130
120
110
100
90
80
70
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Avg. 2016/20
2021
2022
Data Source: KSU Focus on Feedlots, Compiled by LMIC
Livestock Marketing Information Center

43


ELEC. FEEDER CATTLE (@GFQ22)
Print
Symbol: @GFQ22 Go Symbol Search | Symbol Lookup
Historical Chart | Chart | Options | Futures Chain | Spread Matrix
Last: 174.875 | Chg: 3.150 | %Chg: 1.83 | Open: 171.200s | High: 175.275 | Low: 170.000
Current Month: @GFQ22 next
Feb-15 Mar-02 Mar-20 Apr-05 Apr-21 May-09 May-25 Jun-10 Jun-28
@GFQ22 Volume Open Interest RSI

44


ELEC. FEEDER CATTLE (@GFX22)
Print
Symbol: @GFX22 Go Symbol Search | Symbol Lookup
Historical Chart | Chart | Options | Futures Chain | Spread Matrix
Last: 182.025 | Chg: 1.750 | %Chg: 0.97 | Open: 179.500s | High: 182.250 | Low: 178.825
Current Month: @GFX22 prev | next
Feb-15 Mar-02 Mar-18 Apr-05 Apr-21 May-09 May-25 Jun-10 Jun-28
@GFX22 Volume Open Interest RSI

45

Projections

46

Fed Cattle Price Forecast

	Forecast
Jul-Sep	132-136
Oct-Dec	135-139
Jan-Mar 2023	139-149
Apr-Jun 2023	144-154

47

Futures Based Feeder Cattle Price Forecast

	700-800 lb. Steers	700-800 lb. Heifers	500-600 lb. Steers
Aug	171-175	153-157	164-168
Sep	170-174	152-156	161-165
Oct	170-174	153-157	159-163
Nov	168-172	152-156	161-165

- 700-800 lb. load lot price
- 500-600 lb. weekly auction

48

Summary

- Stocker cattle should result in a positive margin
- Cow-calf profitability has improved but depends on input price management
- Potential bull market next 2-3 years

49

Livestock Risk Protection (LRP)

- a risk management tool
- a price insurance policy
- a way to protect against catastrophic price declines
- a way to establish a floor selling price for livestock
- a policy which pays producers if a Regional/National Cash Price Index falls below the covered amount of the expected price

50

Timing and Availability

- Monday-Friday 4 pm Central (5 pm Eastern) thru 9 am Central (10 am Eastern)
- Offerings are based on options market and thus only offered when options market is closed.

51

Basic Information

- Offered for 13, 17, 21, 26, 30, 34, 39, 43, 47, and 52 weeks in advance of potential cattle sell
- Coverage levels range from 70-100% of expected ending price (approximately the futures prices)
- Ownership of cattle must be maintained until 60 days prior to insurance end date

52

Basic Information

- Indemnified based on CME feeder cattle index
- 1-24,000 head covered annually
- 2 weight categories (less than 600 lbs, 600-900 lbs)
- Steers, heifers, predominately brahman, predominately dairy, unborn calves

53

Subsidy Rates

Coverage Level (%)	Subsidy Rate (%)
95.00-100	35
90.00-94.99	40
85.00-89.99	45
80.00-84.99	50
70.00-79.99	55

54

What it looks like

State	County	Endorsement Length	Commodity	Type	Practice	Crop Year	Exp. End Value	Coverage Price	Coverage Level	Rate	Cost Per CWT	Producer Premium Per CWT	End Date	Actual End Value
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$171.570	0.992200	0.036399	6.245	4.06	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$169.570	0.980600	0.030619	5.192	3.37	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$167.570	0.969000	0.025619	4.293	2.79	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$165.570	0.957500	0.021145	3.501	2.28	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$163.570	0.945900	0.017283	2.827	1.70	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$161.570	0.934400	0.014118	2.281	1.37	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September Yr2	2022	172.922	$159.570	0.922800	0.011437	1.825	1.10	09/13/2022	
47 Tennessee	998 All Counties	13	0801 Feeder Cattle	810 Steers Weight 2	309 Endorsement Ending in September	2022	172.922	$157.570	0.911200	0.009101	1.434	0.86	09/13/2022	

55

May your boots still shine!

UTEXTENSION
INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

56

Useful Forage & Nutrient Management Resources

UF/IFAS Nutrient Management Series: Soil Sampling Strategies for Precision Agriculture[1]

Rao S. Mylavarapu and Won Suk Daniel Lee[2]

The purpose of this fact sheet is to help identify different soil sampling strategies, and related advantages and disadvantages, if adoption of Precision Agriculture Technology is being considered.

Precision Agriculture promises to improve fertilizer use efficiency when fertilizer is applied in relation to needs identified by soil tests. Precision Agriculture technology aims at providing the ability to apply nutrients and other inputs for crop production at precise locations in the field, based on the soil test level at that location. Representative soil samples are the key to success of any nutrient management program because the analyses and the resulting nutrient recommendation will only be as good as the soil sample itself. Soil sampling assumes much greater significance when *Precision* or *Site-specific Farming* is adopted, because of the precision and representation required, the variable rates of nutrient calculation and application, and the economics of the technology as a whole. It is extremely important to consider the components of Precision Technology and assess their availability and management when developing a soil sampling strategy. The type of sampling scheme is also site-specific, depending on the factors involved and the goals set.

Soil Sampling and Factors to Be Considered

- **Purpose**: The purpose of soil sampling should be clearly determined prior to beginning a detailed sampling of the area. If one or more of the components of Precision Farming Technology is not available, a traditional sampling and testing approach will probably provide just as much useful data, thus saving the time and money spent on developing a detailed sampling strategy.
- **Resolution**: The high resolution obtained through a high intensity of samples from a given area may not always translate into useful and practical information. The optimum number of samples required from a particular field is often determined from the historical logs and experience of high- and low-yielding areas, areas with identifiable features like depressions, etc. Unless the information gathered from additional samples collected and analyzed can be directly used to improve management and profitability, an intensive sampling should not be attempted. A cost-benefit ratio should be worked out beforehand, because soil sampling and analyses costs can add up very quickly, thus diminishing the returns.
- **Affordability**: Soil sampling needs should be assessed after considering the ability to absorb the costs through

1. This document is SL 190, one of a series of the Department of Soil and Water Sciences, UF/IFAS Extension. Original publication date February 2002. Revised April 2020. Visit the EDIS website at https://edis.ifas.ufl.edu.

2. Rao S. Mylavarapu, professor, nutrient management specialist and director of UF/IFAS ARL/ESTL, Department of Soil and Water Sciences; and Won Suk Daniel Lee, professor, precision farming and remote sensing, Department of Agricultural and Biological Engineering; UF/IFAS Extension, Gainesville, FL 32611.

Reviewed: 01/2022

the initial startup funds, because the returns will not be available until after the harvest season and will depend on the market conditions. The sampling scheme may have to be tried or modified beyond a season or a year in order to evaluate and document the economic returns.

- **Data analyses**: The data generated from the soil tests should be analyzed and interpreted with appropriate perspective that will reflect the site, cropping sequence, and resources available on the farm.
- **Treatment**: A specialized soil sampling scheme should not be developed and implemented if the ability to treat and manage the respective field is lacking. This assessment is crucial, because if the means are lacking, all the gains from variable-rate fertilizer applications will not be realized.
- **Extra mileage**: It is always helpful to gather information from a single soil-sampling trip because additional trips consume time and financial resources.
- **Confidence in the results**: It is important to approach a soil test lab that has a record of consistently offering quality analyses. Similarly, access to fertilizer recommendations that are based on soil test interpretations for the soils and crop(s) to be grown should be evaluated. A high confidence in the results obtained is necessary because comparing the results and recommendations across different labs is strongly discouraged.
- **Soil properties**: Soil samples can be obtained to analyze for both physical and chemical properties. A baseline on soil physical properties, like textural analysis, bulk density, permeability, hardpans, and depth to clay, can be obtained through a onetime assessment. Unlike soil chemical tests, it is not necessary to repeat a physical property test unless a soil amendment is added to ameliorate soil physical conditions like bulk density and hardpan. Field-scale alterations to physical properties like soil texture and depth to clay is not possible. Soil chemical properties include soil pH and extractable plant nutrient levels. Soil testing is recommended every season/year when Precision Technology is adopted for documenting improvements in soil pH and soil fertility levels.
- **Fertilizer recommendation**: The key part of soil sampling and analyses is the fertilizer recommendation that accompanies each soil test report. This forms the basis for all the remaining activities involving inputs into the production cycle. Therefore, it is important to adhere to the rates of nutrients recommended. Altering the recommended rates on soil test reports for the sake of convenience will totally negate the benefits and may result in poor crop performance and economic losses.
- **Traditional soil sampling and testing**: One consolidated sample for every 20-acre area that is uniform is recommended by most soil testing labs and consultants when traditional management methods, are employed. With traditional methods the recommendations are based on entire-field average and so the application of fertilizers is based on the averaged fertility level of the entire field, which is usually at one rate of fertilizer(s). Similarly the yield is averaged for the entire field.

Sampling Process

A base map of the field to be sampled should be constructed by collecting geo-referenced boundaries using GPS (Global Positioning System) equipment. The resolution of the GPS system being used will significantly influence the accuracy of the maps. After the Selective Availability (SA) has been turned off on May 1, 2000, typical GPS positioning error is about 30 ft. It is ideal if the GPS unit can detect distances 10 feet or less. DGPS (Differential Global Positioning System) provides better positioning accuracy (3–10 ft) and is typically used for soil sampling because precise positioning is required. Several computer software packages are available that can download the GPS data and overlay the boundaries on an aerial photograph of the field. A GIS (Geographic Information System) tool like ArcGIS is the most widely used software to draw maps based on geo-referenced information. This process should be repeated for all the sub-areas within the field with identifiable differences. This will enable input applications at variable rates within a field.

Sampling Schemes

Based on the shape and size of individual fields within a farm where crops are to be planted, suitable sampling schemes can be identified.

Grid Sampling

A checkerboard-type grid can be created using special ArcGIS and superimposed on the field map created. The grid approach works best when large tracts of land are available. While these shapes and sizes can be adjusted to suit the need and convenience, the most popular grid sizes used on the mid-western farms are either 2 1/2- or 2-acre grids. Even 1-acre grids are used on areas where a need for intensive sampling is identified. These fixed-area grids will therefore divide the field into equal square-shaped areas from within which samples will be collected. These square-shaped areas are also referred to as “cells.”

A few important aspects of grid sampling must be well-understood before attempting to sample. Samples should be collected at random for adequate representation from within each grid and then consolidated. However, there are at least three methods of sample collection within a grid that are practical. One method is to go to the center of the grid with the GPS unit, walk several steps away from the center in all directions, collect samples from 3–5 spots randomly, and consolidate them (Figure 1). Being relatively simple, this grid-centered approach can be consistently done on any given field. However, for unbiased sampling, care should be taken to avoid concentration of samples around the center point. The second method is to collect samples at random from all across the grid without any bearing on the grid-center (Figure 2). The sampling pattern will not be consistent across the cells, but this approach will ensure a better randomization. This procedure may be more time consuming because various sampling points have to be individually accessed across the grid area. If random accessibility within the grids is severely restricted, samples should be collected diagonally across each cell. In either case the application rates will be uniform throughout each of the cells. The application rates can be varied only among the cells if necessary, depending on the nutrient recommendations.

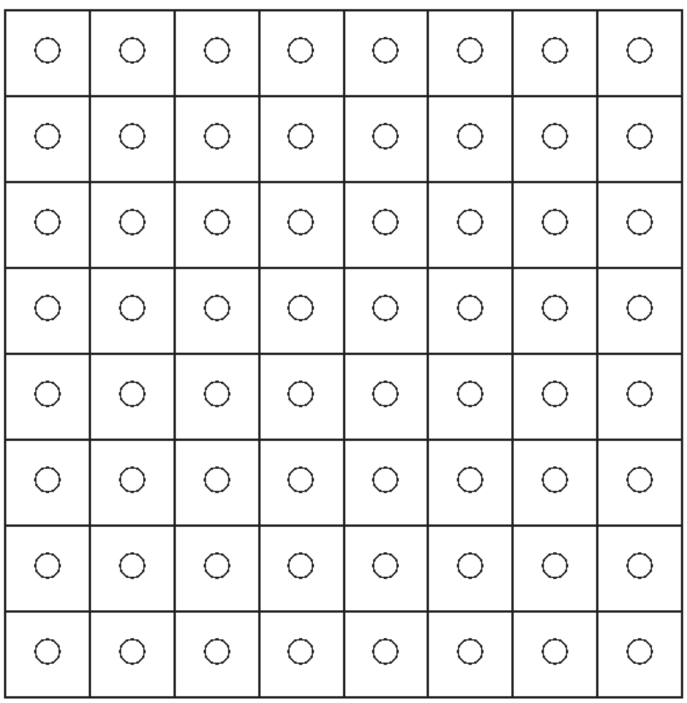


Figure 1. Grid,centered soil sampling.

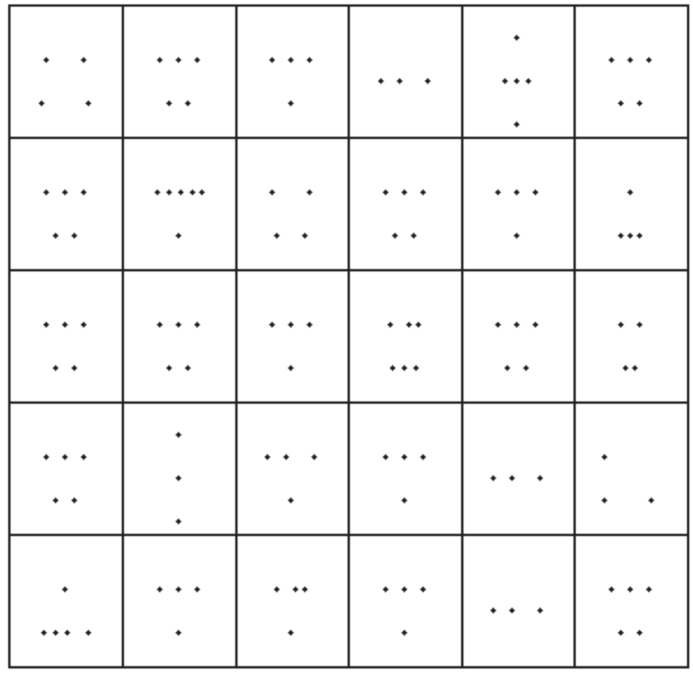


Figure 2. Random sampling within grids.

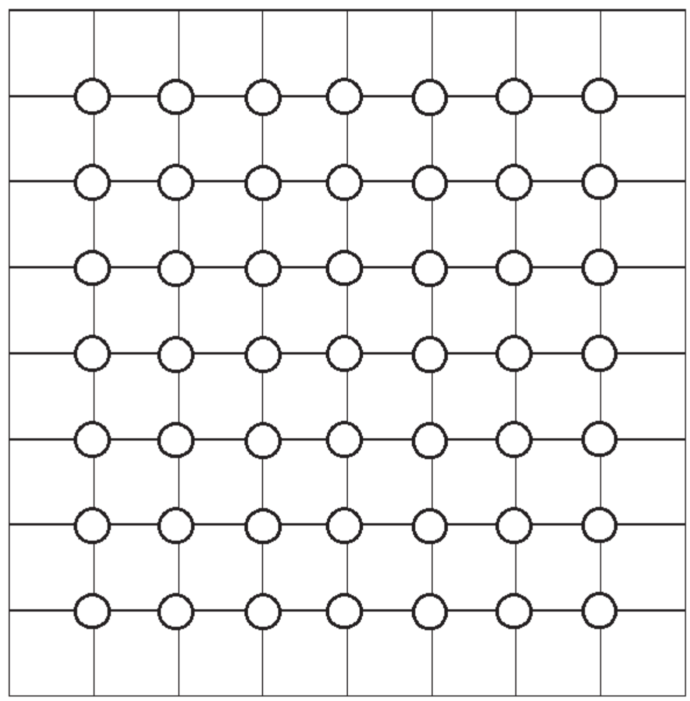


Figure 3. Sampling at the grid intersections.

The third method of grid sampling is to collect samples at grid line intersections (Figure 3). This approach will mathematically integrate the values (interpolate) between the points, which will enable creating contour maps based on the soil nutrient levels. The smaller the grid area chosen, the higher the sampling intensity, thus increasing the costs.

Directed Sampling

A self-directed sampling is another scheme that is often adopted. This method requires a prior knowledge of the site characteristics that may be limiting the yield. Once these low/high,yielding areas, soil types, areas under different cultural management, cropping systems, etc. are identified within a field, maps would be created to delineate the field accordingly and sampling would be conducted within these subregions. However, sampling based on factors that do not influence the yield should be avoided. This will effectively reduce the total number of samples.

Ability to respond to the needs determined from soil sampling and analysis should be the primary factor when designing a sampling scheme. If the capability to vary fertilizer rates and modify or amend the limiting factors is lacking, then the sampling intensity should be considerably reduced. Accruing additional information is expensive and can often cause confusion.

In order to obtain optimum returns, a Directed Sampling scheme developed in conjunction with a good assessment of available resources and the ability to apply nutrients at variable rates is highly recommended. Assessment will be most useful by considering the maximum area or Management Unit across which a fertilizer rate cannot be varied. A Management Unit will be a subunit of the entire field under consideration and representative samples should be randomly collected and composited for analysis. The results will then be averaged across this area, and applications will be made based on averages derived for this unit. Variations, if any, will be made among different units but not within any given unit. This process would be the most effective and economical of all.

A Strategy That Works

Precision, accuracy and reliability are the three main factors that will determine the success of any sampling scheme. Economic feasibility is, of course, the bottom line. The choices look simple, but may not always be easy to make. For this reason alone, help from professional consultants should be sought when Precision Agriculture is being considered.

SL408

Soil Testing for Plant-Available Nutrients—What Is It and Why Do We Use It?[1]

George Hochmuth, Rao Mylavarapu, and Ed Hanlon[2]

Farmers need soil-testing procedures to assess soils for potential plant-available nutrients. Soil testing is the foremost best management practice (BMP). It helps farmers achieve profitable crops while protecting the environment from excessive fertilization and nutrient losses. This publication describes the important steps required to test soil for potential plant-available nutrients. This information will be useful to county UF/IFAS Extension agents when training farmers and crop consultants about proper soil testing and nutrient management.

Scientists generally accept 17 elements as essential for plant growth (Barker and Pilbeam 2007). These elements are carbon (C), hydrogen (H), oxygen (O), phosphorous (P), potassium (K), nitrogen (N), sulfur (S), calcium (Ca), magnesium (Mg), iron (Fe), boron (B), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), nickel (Ni), and chlorine (Cl). A certain amount of each of these nutrients—the crop nutrient requirement (CNR)—is critical for crops to complete their life cycles and to produce an optimal yield. Carbon and oxygen are supplied from air, and hydrogen from water. The remaining nutrients can be supplied from the soil; however, the soil may not always contain enough of these nutrients for optimal crop production. Farmers need to know the portion of the CNR that can be supplied from the soil, because these nutrients are essentially free to the farmer. If the CNR cannot be supplied entirely from the soil, then the soil-supplied nutrients can be augmented with fertilizers or other nutrient sources such as manures or composts. Nearly 150 years ago, scientists developed chemical tests to assess the concentrations of plant-available nutrients in a soil sample and then to use that assessment to make recommendations for supplemental fertilizer.

What is soil testing?

The Soil Science Society of America defines soil testing as "the application of soil science research to the rapid chemical analyses to assess the available nutrient status of a soil." Agronomic soil tests do not measure the total amount of a plant nutrient in the soil, or even the exact amount of plant-available nutrient for the season. Soil tests provide an index (i.e., indication, or assessment) of the nutrient-supplying capacity of the soil (see "Soil text index" section below). Soil testing is most applicable to nutrients of low mobility in soils—such as P, K, Mg, Ca, and micronutrients—because these nutrients will remain in the soil after the soil has been tested. This low mobility is in contrast to mobile soil nutrients—such as nitrogen—that may rapidly transform or leach from the soil in the time between soil testing and crop planting.

Why do we use soil testing?

We test soil to determine how to get the best crop yields and how to use fertilizer and other nutrient sources most efficiently. When soil testing was originally developed, the

1. This document is SL408, one of a series of the Department of Soil and Water Sciences, UF/IFAS Extension. Original publication date May 2014. Reviewed December 2017. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. George Hochmuth, professor; Rao Mylavarapu, professor; and Ed Hanlon, professor emeritus; Department of Soil and Water Sciences, UF/IFAS Extension, Gainesville, FL 32611.

Reviewed: 01/2022

goal was to enhance crop yields by identifying productive soils. Today, crop productivity is still a goal, but another goal is to avoid excessive fertilizer applications and, thereby, protect the environment.

The soil test is a process that includes the following five activities: (1) collecting the soil sample, (2) processing the soil sample in the lab, (3) analyzing the sample for its extractable nutrient content, (4) interpreting the results of the analysis, and (5) using the information to make a fertilizer recommendation (Sikora and Moore 2014). Activities 1 through 4 are discussed in this publication, and activity 5 is discussed in the EDIS publication SS623, *Fertilizer Recommendation Philosophies* (Hochmuth et al. 2014).

Collecting the Soil Sample

The usefulness of the soil-testing process depends on the quality of the soil sample. A quality soil sample is representative of the soil for the field in question, and a quality sample is collected properly, in terms of depth and numbers of subsamples.

Depth

Soil samples for predicting fertilizer needs are collected from the top six inches of soil in the field, because the top six inches is the part of the soil typically tilled with plows and disks and the upper six-inch layer of soil also contains a large portion of the nutrient-absorbing roots.

Number of Subsamples

Before sampling, the field should be divided into "management units," which are representative of areas that will receive different cultural practices, such as different crops or different planting dates (Figure 1). Management units may also represent soil types with different native mineral composition. (Current management units may be different from previous cropping-system-management units and may also have different nutrient content.) Your different management units should be sampled separately, because they may require different approaches to fertilization. A large field may have enough inherent variability to justify determining individual management units of 20 to 40 acres. To take a soil sample from a management unit, first collect 20 subsamples with a soil sampling probe, and then composite the subsamples in a plastic bucket and mix them. Take a sample volume of about a half-pint from the bucket of mixed soil and submit it to the lab in the paper bag provided for soil-testing submissions. Additional information on management units and soil sampling schemes can be found in the EDIS document SS402, *UF/IFAS Nutrient Management Series: Soil Sampling Strategies for Precision Agriculture* (Mylavarapu and Lee 2014).

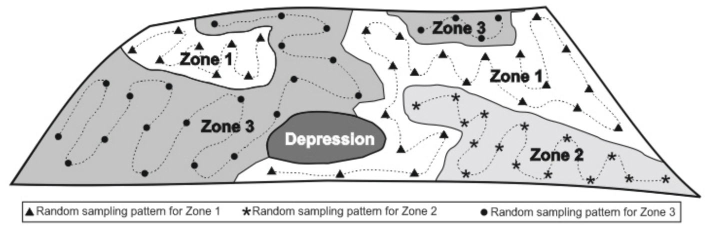


Figure 1. Scheme illustrating random soil sampling on a commercial agricultural farm or a landscape.
Credits: Greg Means, UF/IFAS

Additional Information Needed

In addition to the soil sample, the lab will require you to fill out some forms to provide information about the crop to be grown and the specific nutrient analyses being requested. This information will help the lab make the best fertilizer recommendation for the farmer.

Soil Sampling and Precision Agriculture

Typically, soil testing and fertilizer recommendations are made for the entire management unit, even though there may be considerable variation across the management unit, which may be 20 acres in size. However, some growers are adopting precision agricultural techniques. For example, some farmers are applying fertilizers in precise techniques where the fertilizer rate is varied throughout a field according to the nutrient levels in the soil. Precision agriculture uses *variable-rate application* of fertilizers so that areas in the field needing more or less fertilizer can receive the appropriate rate. For variable-rate application to work, soil samples need to be taken on a more detailed basis. One way to take more detailed soil samples is to use a grid-sampling approach. Grids may be as small as two acres each. Other techniques for variable-rate application of fertilizers have been based on changes in soil type as described by Natural Resources Conservation Service (NRCS) soil maps, yield maps derived from previous crop yields, and various combinations of these and other techniques (Mylavarapu and Lee 2014).

Processing and Analyzing the Soil Sample

When the sample arrives at the laboratory, most labs analyzing agricultural soils use the following steps:

1. The soil is dried at approximately 100°F to remove soil moisture.

2. The soil is sieved to remove old plant parts and stones. A clay-dominated soil may need pulverizing to break up clods.

3. A small portion of the sample is taken for processing in the lab.

4. The soil sample is mixed (usually by shaking) with a solution called an "extractant."

5. After mixing, the sample's liquid portion is filtered and analyzed for its nutrient content. Analytical equipment will vary, depending on the nutrients being determined and the individual lab design and setup.

6. The concentration of extracted nutrient from the liquid portion is converted to the dried-soil basis and is referred to as the *soil-test index*.

7. The index is then given an *interpretation* as to the ability of that soil to provide enough of a nutrient for optimal crop yield. For example, a *low* interpretation means that the soil cannot supply all of a particular nutrient for crop production. A *high* interpretation, however, means that the soil can supply all of a particular nutrient for crop production.

8. The final step is for the lab to make a fertilizer recommendation for those soil samples that received interpretations of less than *high*. The fertilizer recommendation provides the recommended rate, but the rate is not the only part of a recommendation. A complete recommendation also contains guidelines about placement and timing of the fertilizer application, which can help farmers use fertilizer efficiently while also protecting the environment.

The Role of Soil Test Extractants

The extractant, a solution that is mixed with the soil sample, is crucial to the soil test. Briefly, the extractant is developed for specific types of soils and growing conditions, such as soil reaction (pH) and the need for micronutrient results. The extractant is often a solution of various chemicals including water, acids, and certain organic chemicals. For example, the UF/IFAS Extension Soil Testing Lab now uses the Mehlich-3 soil test extractant—which is composed of acetic acid, ammonium nitrate, nitric acid, ammonium fluoride, and ethylene diamine tetra acetic acid (EDTA). There are at least a dozen soil test extractants in common usage by agricultural soil testing labs in the United States, but not all extractants are useful for all agricultural regions. Each extractant was developed to meet particular goals, but some extractants were developed to have wide applicability among soil types and tested nutrients. These latter extractants are called *universal extractants*, and Mehlich-3 is one such extractant. The Mehlich-3 extractant is more applicable than Mehlich-1 (used by UF/IFAS Extension until August 2013) for Florida's high-pH agricultural soils (Mylavarapu et al. 2014).

Interpreting the Results of the Soil Test Index

As mentioned earlier, the concentration of nutrients extracted from the soil sample is called an *index*. The soil test index is an indication of the soil's nutrient-supplying capacity and its expected relative yield (Table 1). The total amount of a nutrient in the soil is of little importance in determining fertilizer recommendations, because only a portion of a nutrient may be available for plant use during the growing season. For example, a soil's nutrient availability includes a myriad of chemical reactions that a nutrient may undergo with time, and a nutrient may reside in multiple forms (some insoluble). Therefore, the soil test index is often referred to as an *availability index*. The availability index tells us, based on previous research, the relative level of a nutrient that will probably contribute to the crop nutrient requirement during the growing season.

Table 1. Soil-test-index interpretation with expected crop yield.

Low	**= less than 75%**
Medium	**= 75% to 100%**
High	**= 100% of expected yield**

The extractant used by a lab must be *correlated* with crop response (Mitchell and Mylavarapu 2014). This correlation means that if the extracting process results in a low interpretation, then that unfertilized soil will produce a low-yield crop. If the extracting process results in a high interpretation, then the unfertilized soil will produce a high-yield crop. Further, the extractant must be *calibrated*, which means that the lab using the extractant can accurately associate a fertilizer recommendation with each soil test result interpretation. The greatest amount of fertilizer will be recommended for *low*-testing soil, less for medium-testing soils, and likely no fertilizer for *high*-testing soils.

Sometimes farmers send a portion of the same sample to several labs and question why the soil test indexes are different among labs. The use of different extractants probably explains the difference. There must be considerable soil testing and crop response research conducted to develop the soil test. Farmers should ask the lab about the particular soil test extractant and its research base. We will discuss correlation and calibration in more detail in EDIS publication SS622, *How a Soil Test Is Developed—Correlation and Calibration* (Hochmuth, Mylavarapu, and Hanlon 2014).

Important Guidance about the Soil Test Index

The soil test index is usually expressed as a nutrient concentration in the air-dry soil. For example, it may be expressed in parts per million (ppm) or milligrams per kilogram (mg/kg). These two expressions are equivalent. The instruments accurately determine the nutrient concentration in the soil using these units of expression.

However, these determinations are occasionally converted into other units for making fertilizer recommendations. In doing this, sometimes an inaccurate and faulty assumption is made—that an acre of six-inch-deep surface soil weighs 2 million pounds. Using that faulty assumption, the concentration value (ppm) is multiplied by 2 to result in the new expression of "pounds per acre." The inaccuracy occurs because soils of different textures and organic-matter contents result in different bulk densities of soils and will, therefore, have differing mass per unit volume.

Another potential fallacy of this particular conversion approach is that the expression "pounds per acre" may be open to misuse in making fertilizer recommendations. Even if the expression "pounds per acre" is employed, it is still an index and must be interpreted as *low*, *medium*, or *high*. The index "lb per acre" cannot be used directly to determine a fertilizer amount by arithmetic.

EXAMPLE

Let's assume the maximum phosphorus (P_2O_5) for a crop is 150 lb per acre (this rate would only be recommended on a *low* index), and further assume that the soil test index was 25 ppm for a submitted soil sample. The index was converted to 50 lb/acre of P by multiplying the concentration index by 2 as explained above. Next, to convert the index from lb/acre P to lb/acre P_2O_5, the index is multiplied by 2.3 to get 115 lb per acre P_2O_5. Then, 115 is subtracted from 150 to get 35 lb per acre P_2O_5, and this rate is used as the fertilizer recommendation.

This series of calculations and assumptions result from a misunderstanding of the soil test index. Using the current IFAS Mehlich-3 interpretation, the index of 25 would be interpreted as *low* and a recommendation of 150 lb per acre of P_2O_5 would be recommended, not 35 lb. So, a concentration index should not be converted to a rate value such as lb per acre, because the index is a concentration and must be interpreted before a recommended fertilizer rate can be determined. Conversion of the index in ppm to another unit (such as "pounds per acre") is unnecessary, and it does not matter if the index is in elemental or oxide form, in the case of phosphorus or potassium.

Frequency of Soil Testing

Soil testing should be a regular, annual process in most cases. However, for high-value crops, soil testing should be carried out on a seasonal basis. Records (see "Soil test and fertilization records" section below) of soil testing results are important to help determine sampling frequency. For example, if several successive years of soil testing show no decline in the index for a particular nutrient, then sampling frequency can be reduced to every two or three years. Unless farmer experience and records indicate otherwise, annual soil testing is recommended in Florida. Buildup of nutrients is less likely to happen in our sandy, low cation-exchange-capacity soils, so annual soil testing will help you avoid planting crops on low nutrient-content soils.

Soil Test and Fertilization Records

Farmers should maintain records of a field's soil test history and fertilization practices. These records will help track fertilizer inputs and can help increase the efficiency of fertilizer use. Records will also help track buildup of certain nutrients that may be detrimental to crop productivity and may have negative environmental impacts. For example, if phosphorus builds up to excessive levels, then loss of soil by erosion could result in phosphorus enrichment of a nearby water body. Or, as another example, leaching may be a problem in some sandy soils of Florida.

Summary

Soil testing is important for determining the portion of the crop nutrient requirement that can be supplied from the soil. Soil testing is most effective in regard to nutrients that are not highly mobile in the soil. Soil testing is an important best management practice. Farmers practicing correlated and calibrated soil testing will benefit from proper fertilizer-rate applications and will protect the environment from nutrient pollution due to inappropriate fertilization practices.

Other Publications in this Series on Soil Testing

Hochmuth, George, Rao Mylavarapu, and Ed Hanlon. 2014. *Developing a Soil Test Extractant—The Correlation and Calibration Processes*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss622.

Hochmuth, George, Rao Mylavarapu, and Ed Hanlon. 2014. *Fertilizer Recommendation Philosophies*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss623.

Hochmuth, George, Rao Mylavarapu, and Ed Hanlon. 2014. *The Four Rs of Fertilizer Management*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss624.

References

Barker, A. V., and D. J. Pilbeam. 2007. *Handbook of Plant Nutrition*. CRC Press, Taylor and Francis Group. Boca Raton, FL.

Mitchell, C. C., and R. Mylavarapu. 2014. *Soil Test Correlation and Calibration for Recommendations.* In *Soil Test Methods from the Southeastern United States*. Southern Cooperative Series Bulletin No. 419. USDA-SERA-IEG-6. ISBN 1-58161-419-5.

Mylavarapu, R., and W. D. Lee. 2014. *UF/IFAS Nutrient Management Series: Soil Sampling Strategies for Precision Agriculture*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss402.

Mylavarapu, R., T. Obreza, K. Morgan, G. Hochmuth, V. Nair, and A. Wright. 2014. *Extraction of Soil Nutrients Using Mehlich-3 Reagent for Acid Mineral Soils of Florida*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss620.

Sikora, F. J., and K. P. Moore (eds.). 2014. *Soil test methods from the southeastern United States*. Southern Cooperative Series Bulletin No. 419. ISBN 1-58161-419-5.

SS-AGR-176

Fertilizing and Liming Forage Crops[1]

Y. C. Newman, C. Mackowiak, R. Mylavarapu, and M. Silveira[2]

Plants require many essential nutrients for growth. To be specific, they require 17 of them. Those nutrients required by plants in large quantities are called macronutrients, and they can be either primary or secondary. Primary macronutrients are required in high quantities and they are nitrogen (N), phosphorus (P), and potassium (K). Those required in moderate quantities are called secondary nutrients, and they are calcium (Ca), magnesium (Mg), and sulfur (S). There are also nutrients that are needed in very little amounts but are as essential for plant growth as the macro and secondary nutrients, and they are called micronutrients (iron, copper, zinc, manganese, boron, molybdenum, chlorine, and nickel). The soil can supply the plant with most, if not all, of the macro - secondary, and micronutrients, but often the supply of one or more of the nutrients is insufficient for optimum growth.

Nitrogen is the nutrient that grass pastures use the most, and when used in a balanced fertilization, it often results in increased forage quality and production. Phosphorus may be deficient in some soils, but other Florida soils are high in native P. Some forage crops may extract sufficient P from the subsoil, even when the P level in the surface soil is low. Potassium (K) may be needed by some forage crops. Under intensive hay or silage production where nutrients are removed from the land, annual applications of N, P, and K are typically required. Potassium is fairly mobile in sandy soils and can quickly become deficient. Calcium, magnesium, sulfur, and some micronutrients may also become deficient in the soil if soil fertility is overlooked.

While routine soil tests do not include a micronutrient analysis, it is suspected that in some areas of Florida S deficiency may be seen in some years and on some crops. Sulfur deficiency may be seen under intensive hay or silage production. Sulfur deficiency symptoms are pale green leaves mainly in young leaves, similar to nitrogen deficiency, but nitrogen deficiency symptoms show pale leaves in older and new leaves. If a producer is concerned or suspects a sulfur deficiency, some sulfur may be added by using ammonium sulfate as the nitrogen source in the first spring application (just be aware that ammonium

1. This document is SS-AGR-176, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date March 2003. Revised January 2008 and March 2014. Reviewed July 2017. Visit the EDIS website at http://edis.ifas.ufl.edu. This publication is also part of the *Florida Forage Handbook*, an electronic publication of the Agronomy Department, originally written by C.G. Chambliss; revised by Yoana Newman. For more information you may contact the editor of the *Florida Forage Handbook*, Y. C. Newman (ycnew@ufl.edu).

2. Y. C. Newman, assistant professor, Agronomy Department; C. Mackowiak, assistant professor, Department of Soil and Water Sciences; R. Mylavarapu, professor, Department of Soil and Water Sciences; and M. Silveira, associate professor, Department of Soil and Water Sciences; UF/IFAS Extension, Gainesville, FL 32611.

sulfate is an acidifying fertilizer). Use of other S fertilizers such as sul-po-mag or gypsum is another option when no additional N is needed or if your pH is moderately acidic.

Under most circumstances, micronutrients are not deficient in pastures and therefore should not be applied until a deficiency of a specific nutrient is confirmed. A suggestion for new plantings of forages on unplanted and unfertilized flatwood soils is to apply 3 lb./acre of copper with the initial fertilization.

Only the nutrients that are needed by the crop should be included in the fertilizer. For example, if a soil test indicates that phosphorous is adequate, no phosphorus should be included in the fertilizer. Banking fertilizer in the soil is not a profitable method for managing the nutrition of crops, plus there is a high risk of environmental pollution.

How does a manager decide if fertilizer or lime should be applied to a pasture or forage crop? Fertilizer and/or lime should be applied if (1) an increase in forage growth can be expected, (2) if the extra forage is needed, and (3) a return on the investment can be expected. The experience of the forage manager, along with soil testing for pH, P, and K, can be used in making a decision about liming and fertilizing with P and K especially for hay or silage production. There is no point in fertilizing to reach maximum yields if the extra forage produced is not used. To make a profit on the investment, the forage must be utilized or harvested, and the product (animal weight gain, milk, hay, or silage) must be marketed.

Fertilizer should usually be applied at the beginning of the growing season. Warm-season perennial grasses should be fertilized in the early spring (February to March). Spring fertilization stimulates production at a critical time. Some pasture grasses may be given an additional application of N in late season (June) if extra forage is needed, but this is usually not the case for a beef cow/calf operation. The June or late season application is recommended as long as there is no standing water or the water table is not near the surface, in which may cause environmental problems. Although bahiagrass gives little, if any, response to a late-summer/fall application, limpograss, rhodesgrass, and stargrass do. These grasses can be fertilized in the late summer or early fall to extend the grazing season or, in the case of limpograss, for stockpiling. Timely application of fertilizer can be used to increase forage yield and quality, improve stand persistence, and provide for better distribution of forage across the growing season. The producer should consider that the response obtained from an application of fertilizer is influenced by other factors, such as solar radiation, temperature, soil moisture, and grazing management. For example, overgrazing or excessive defoliation limits the ability of the plant to respond to the added nutrients and thereby reduces potential yield.

Some grasses, such as the stargrasses and some of the hybrid bermudagrasses, need to be fertilized annually or maintained in a high-fertility environment in order to keep a good stand. On the other hand, some ranch managers with large, extensive operations may only fertilize their bahiagrass once every three years. This grass can persist under minimum fertility if they are not overgrazed or mismanaged.

Fertilization Recommendations for Specific Forages

Fertilizing for Establishment of Perennial Grasses

Applying nutrients on a clean-tilled seedbed before plant roots are present increases the risk of losing the nutrients through leaching. Heavy rainfall events on the sandy soils of Florida can move nutrients downward in the soil profile and out of reach of plant roots that will be developing later. Therefore, it is suggested that, where possible, nutrients (fertilizer) not be applied until plant roots are present to take them up. On the other hand, biosolids, poultry litter, manures, and composts can be lightly incorporated into the seedbed. They have a slower nutrient release than mineral fertilizers and the organic matter may provide some additional tilth and moisture retention to the soil.

For establishment of new plantings, apply 100 lb. N/acre and split application as follows: apply 30 lb. N/acre, all of the soil test recommended P_2O_5, and 50% of the K_2O as soon as plants emerge. Apply the remaining K_2O and 60–70 lb. N/acre 30–50 days later.

When the new plants are small, only a limited amount of N and K_2O are applied, with additional N and K_2O being applied later to encourage the new plants to continue growing, spreading, and developing into a full and complete stand of grass.

Fertilizing Bahiagrass

GRAZED BAHIAGRASS

Phosphorus Fertilization

In order to receive phosphorus fertilizer recommendations for established bahiagrass, soil AND tissue samples should be submitted to the Extension Soil Testing Lab (ESTL) at the same time. As per the preliminary research findings, soil tests alone are not adequate to determine bahiagrass P needs. A companion tissue test has therefore been added to the testing procedures along with the soil test to determine the P fertilization needs. Producers are strongly encouraged to simultaneously test soil and tissue samples if bahiagrass pastures have not received P fertilization for long periods. Phosphorus should not be applied if tissue P concentrations are at or above 0.15%, even if soil tested Low in P. For Medium and High soil P levels, P application is not recommended since there is no added benefit of P fertilization on bahiagrass yields.

If P recommendations are not desired and the producer is only interested in either the test for soil pH and lime requirement recommendations or the test for soil pH, lime requirement, K, Mg, and Ca recommendations, the soil sample alone can be submitted to the ESTL. In this case, the soil test report will not include P fertilizer recommendations. (Please choose the appropriate test from the Producer Sample Submission Form.)

Both the consolidated representative soil and the tissue samples should be collected simultaneously from each field of up to 40 acres.

ESTL testing procedures and recommendations for P for bahiagrass may be adjusted as and when field research data becomes available.

MAINTENANCE FERTILIZATION

Four fertilization options are presented below for established bahiagrass pastures. Choose the option which most closely fits your fertilizer budget, management objectives, and land capability. If you will be grazing only your bahiagrass, you should carefully consider the potential for economical return on your investment in fertilizer before using the Medium-Nitrogen or High-Nitrogen options described below. The added forage produced for grazing animals may not be worth the added cost.

- *Low-Nitrogen Option*: Do not use this option if you cut hay, since nutrient removal by hay is much greater than by grazing animals. This option results in the lowest cost of purchased fertilizer. Apply 50–60 lb. N/acre in the early spring. Do not apply K, recognizing that N will be the limiting nutrient in this low-cost option. Apply 25 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Do not apply P if tissue P concentration is at or above 0.15%, even if the soil tests Low in P. For Medium and High soil P levels, neither P application nor tissue analysis is recommended since there will be no added benefit of P fertilization on bahiagrass yields.
- *Medium-Nitrogen Option*: Apply 100 lb. N/acre in the early spring. Apply 25 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Do not apply P if tissue P concentration is at or above 0.15%, even if the soil tests Very Low or Low in P. For Medium and High soil P levels, neither P application nor tissue analysis is recommended since there will be no added benefit of P fertilization on bahiagrass yields. Apply 50 lb. K_2O/acre if your soil tests Low in K and none if it tests Medium or High.
- *High-Nitrogen Option*: Apply 160 lb. N/acre in two applications of 80 lb. N/acre in early spring and early summer. Apply 40 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Do not apply P if tissue P concentration is at or above 0.15%, even if the soil tests Low in P. For Medium and High soil P levels, neither P application nor tissue analysis is recommended since there will be no added benefit of P fertilization on bahiagrass yields. Apply 80 lb. K_2O/acre if your soil tests Low in K and 40. lb. K_2O/acre if it tests Medium. No K should be applied if your soil tests High in K. The fertilization rates suggested in this option are high enough to allow bahiagrass pasture to achieve well-above-average production. Management and environmental factors will determine how much of the potential production is achieved and how much of the forage is utilized. A single cutting of hay can be made without need for additional fertilization.

BAHIAGRASS CUT SOMETIMES FOR HAY

For a single cut per year from pastures:

- If you used the **Low-N option** of pasture fertilization, apply 80 lb. N/acre no later than six weeks before the growing season ends. Apply 50 lb. K_2O/A if your soil tests Low in K, and none if it tests Medium or High. Apply 25 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Do not apply P if tissue P concentration is at or above 0.15%, even if the soil tests Very Low or Low in P.
- If you used the **Medium-N option** of pasture fertilization, apply an additional 80 lb. N no later than six weeks before the growing season ends. Apply 50 lb. K_2O/acre if your soil tests Low in K, and none if it tests Medium or High. Apply 25 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%.
- If you used the **High-N option** of pasture fertilization, you do not need any additional N fertilization to make

one cut of hay. Apply 80. lb. K_2O/acre if your soil tests Low in K and 40 lb. K_2O/acre if it tests Medium. Apply 40 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%.

BAHIAGRASS GROWN ONLY FOR HAY

For multiple cuts of hay: Apply 80 lb. N/acre in early spring. Also in spring, apply 80 lb. K_2O/acre if your soil tests Low in K, and 40 lb. K_2O/acre if it tests Medium. Apply 40 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Apply an additional 80 lb. N and 40 lb. K_2O/acre after each cutting, except the last in the fall. Include 20 lb. of P_2O_5/acre after each cutting if the soil tested Low in P.

BAHIAGRASS FOR SEED PRODUCTION

Apply 60–80 lb. N/acre in February or March. At the same time, apply 80 lb. K_2O/acre if your soil tests or Low in K, and 40 lb. K_2O/acre if it tests Medium. Apply 40 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Graze until May, June, or July, depending on variety. Remove cattle before seed heads start to emerge, and apply an additional 60–80 lb. N/acre.

If the bahiagrass is not grazed, do not apply fertilizer in February or March since this may stimulate excessive top growth. Mowing from February to April may be needed to remove excessive top growth. Apply 60–80 lb. N/a before seed heads first appear. Apply 25 lb. P_2O_5/acre if your soil tests Low in P and tissue P concentration is below 0.15%. Do not apply P if tissue P concentration is at or above 0.15%, even if the soil tests Very Low or Low in P. For Medium and High soil P levels, neither P application nor tissue analysis is recommended. Apply 50 lb. K_2O/acre if your soil tests Low in K and none if it tests Medium or High. Fertilize Pensacola in March/April and Argentine and Paraguay in May/June.

Special Note if Applying Manure or Biosolids

A different set of economic factors are usually considered when waste materials rather than purchased fertilizer are supplying the nutrients. Additionally, it is often impractical to follow the application timings discussed in this publication when using waste materials from other operations.

Fertilizing Established Pastures of Bermudagrass, Stargrass, Digitgrass (Pangola), Rhodesgrass, and Suerte

For grazed stands, apply 80 lb. N/acre, all of the soil test recommended P_2O_5, and 50% of the K_2O in early spring. Apply an additional 60–80 lb. N/acre and the remaining K_2O at midseason. In central and south Florida, the midseason application can be delayed and applied in September to early October for fall production on stargrass, hybrid bermudagrasses, and rhodesgrass. Under intensive management in central and south Florida, up to 200 lb. N/acre/year may be economically viable for stargrass and bermudagrass. In this situation, apply 80 lb. N/acre, all of the P_2O_5, and 50% of the K_2O in early spring. Follow with 50 lb. N/acre in midseason, and 70 lb. N/acre and the other 50% of the K_2O in mid-to-late September.

Fertilizing Established Pastures of Limpograss

For grazed stands, apply 60 lb. N/acre and the entire soil test recommended P_2O_5 and K_2O in late winter or early spring. Apply an additional 60 lb. N/acre in late summer or early fall. For a minimum fertilization alternative, ignore the P and K recommendation and apply only 60 lb. N/acre/year.

Fertilizing for Hay or Silage Production from Perennial Grasses (excluding bahiagrass)

For multiple cuts: Apply 80 lb. N/acre and all of the recommended P_2O_5 and K_2O in early spring. Apply an additional 80 lb. N and 40 lb. K_2O/acre after each cutting, except the last in the fall. Include 20 lb. of P_2O_5/acre in the supplemental fertilizer if the soil tested low or medium in P.

For a single, late season cut from pasture: Apply 80 lb. N/acre if you have not applied N in the past two months, and apply the soil test recommended amount of P_2O_5 and K_2O. If you have applied N in the past two months, do not apply any nitrogen now, but do apply the soil test recommended amount of P_2O_5 and K_2O. Any application of fertilizer should be made no later than six weeks before the growing season ends.

Summer Annual Grasses

Species included are sorghum-sudan hybrids, pearl millet, brown top millet, and Japanese millet.

Apply 30 lb. N/acre, 50% of the soil test recommended K_2O, and all of the P_2O_5 fertilizer in a preplant or at-planting application. Apply 50 lb. N/acre and the remaining K_2O after the first grazing period. Apply an additional 50 lb. N/acre after each subsequent grazing period, except the last.

Warm-Season Legumes or Legume-Grass Mixtures

Species included are aeschynomene, Alyce clover, desmodiums, hairy indigo, stylo, perennial peanut, and other tropical legumes. Apply all of the soil test recommended P_2O_5 and K_2O in spring or early summer when seedlings or regrowth are 3–4 inches tall.

Perennial Peanut Hay Production

Apply all of the soil test recommended P_2O_5 and K_2O in early spring. Make an annual application of 20–30 lb. sulfur/acre applied as a sulfate (e.g., gypsum, ammonium sulfate, magnesium sulfate, potassium sulfate, potassium magnesium sulfate). After each hay harvest, apply an additional 15 pounds of P_2O_5 and 40 pounds of K_2O per ton of hay removed, unless the soil tests high or very high.

Cool-Season Annual Grasses

When planting on a prepared seedbed, apply 30 lb. N/acre, 50% of the soil test recommended K_2O, and all of the P_2O_5 fertilizer in a preplant or at-planting application. Apply 50 lb. N/acre and the remaining K_2O after the first grazing period. Apply an additional 50 lb. N/acre after each subsequent grazing period. When overseeding established perennial grasses with cool-season annual grasses, apply 50 lb. N/acre plus all of the P_2O_5 and K_2O after emergence. Apply an additional 50 lb. N/acre after each subsequent grazing period.

Cool-Season Legumes or Legume-Grass Mixtures

Species included are all true clovers (white, red, arrowleaf, crimson, subterranean), vetches, lupines, and sweet clover. If legumes such as white clover are already established, or if reseeding annual legumes such as crimson clover are re-establishing from natural seed, apply all of the soil test recommended P_2O_5 and K_2O fertilizer in late fall. For new plantings, apply the recommended P_2O_5 and K_2O in a preplant or at-planting application. If legumes are planted in combination with oat, rye, wheat, and/or ryegrass, apply 30 lb. N/acre in a preplant or at-planting application plus one additional 50 lb. N/acre application after the grass is well established. These recommendations are made assuming adequate soil moisture is available from either rainfall or irrigation. In southern Florida, lack of adequate rainfall during the cool season frequently causes stand failure or limits growth. Under nonirrigated conditions in southern Florida, the probability of inadequate moisture is high and the likelihood that the crop will benefit from applied fertilizer is low, especially on the drier soils.

Alfalfa

Apply all of the soil test recommended P_2O_5 and 50% of the K_2O fertilizer in late fall. Apply the remaining K_2O in early spring. If the alfalfa is mechanically harvested rather than grazed, apply an additional 30 lb. P_2O_5 and 60 lb. K_2O/acre after each harvest. An additional application of 100 lb. K_2O/acre in June or July may increase summer survival of alfalfa. Apply 3 lb. boron/acre per year to alfalfa in three 1 lb./acre applications. Copper and zinc fertilizer may be needed if soil pH is above 6.5. The lime requirement shown on the soil test report is adequate for established alfalfa. However, if the alfalfa has not yet been planted, apply and incorporate one ton of lime/acre if the soil pH is below 6.6. Lime is especially important for alfalfa establishment. It is not practical to incorporate lime once the alfalfa is planted. Fertilizer should contain 15–20 lb. sulfur/acre; apply as a sulfate (e.g., gypsum, ammonium sulfate, magnesium sulfate, potassium sulfate, potassium magnesium sulfate) since elemental sulfur reacts too slowly to supply the sulfur needs of the current crop and elemental sulfur may decrease soil pH.

Liming

The primary reasons for liming acidic soils are to increase crop yield and to enhance fertilizer efficiency. Lime also affects the solubility of other elements; therefore, some plant nutrients are made more available by liming, while toxicities caused by excessive concentrations of other plant nutrients are reduced. In addition to neutralizing soil acidity, calcitic limestone supplies the plant nutrient calcium, and dolomitic limestone supplies both calcium and magnesium. While a correct liming program is beneficial for plant growth, excessive liming can be detrimental. Deficiencies and imbalances of certain plant nutrients may result from excessive lime application.

To obtain maximum benefit from liming and to determine the type and quantity of lime to apply, soil and plant factors must be taken into account. The first step is to properly collect a soil sample from the area to be limed. Samples are normally taken to a depth of 4–6 inches. The soil sample should be sent to a reputable soil testing laboratory for determination of pH and lime requirements.

Lime should be incorporated into the soil whenever possible since lime reacts with soil that it comes in contact with. However, it has little immediate effect on the soil pH below the top inch or so. Therefore, lime should be applied and incorporated 3–6 months prior to planting. The frequency of lime application will depend on many factors, including fertilization program, soil type, and crop. Typically, lime application should seldom be more frequent than every three years, with the exception of intensive hay fields that receive high ammonium-nitrogen fertilizer application rates.

If the soil is at or above the target pH, soil calcium in the soil should be sufficient for optimum plant growth. If the soil pH needs to be increased and the level of magnesium is low, liming with dolomitic limestone is a relatively inexpensive method for adjusting the pH and supplying magnesium. Magnesium can be added to the fertilizer.

The target pH for various forage crops is listed in Table 1. All of the recommendations shown in Table 1 are part of the standardized fertilization recommendation system of the UF/IFAS Extension Soil Testing Laboratory. Cool-season legumes are pH-specific, and most of them require high pH of 6 or higher. Warm-season perennial grasses, on the other hand, perform well at a lower pH. Appropriate lime recommendations are automatically recorded as part of the soil test report.

Other Important Considerations

When applying manure, biosolids, and waste materials, producers may apply higher rates than those recommended for mineral fertilizers since the nutrients present in the waste materials need to be converted into forms that the plants can use. However, the producer should not go above rates that are environmentally acceptable. Additionally, timing of nutrient application may be different than those previously recommended.

When applying lime-stabilized biosolids, attention should be given to the liming effect of this material. Soil pH should be carefully monitored to avoid pH conditions above 6.5. It has been demonstrated that bahiagrass growing in soil conditions of pH 7.0 or above will, very likely, perform poorly compared to bahiagrass growing at lower pH conditions.

For additional information see:

- EDIS IFAS fact sheet SL179 *Using Waste Products in Forage Production*.
- EDIS IFAS fact sheet SS-AGR-152 *Fertilization of Agronomic Crops* for a more extensive discussion of micronutrients.
- Forages of Florida website at http://agronomy.ifas.ufl.edu/ForagesofFlorida/index.php.

Table 1. Target pH for different forage crops grown on mineral soils.

Crop Category	Crops Included	Target pH
Bahiagrass	bahiagrass	5.5
Other improved perennial grasses	bermuda, star, rhodes, suerte, and digitgrass	5.5
	limpograss	5.0
Warm-season annual grasses	corn, sorghum, sorghum-sudans, and millets	6.0
Cool-season annual grasses	small grains and ryegrass	6.0
Warm-season legumes or legume-grass mixtures	perennial peanut, stylo, desmodiums, aeschynomene, Alyce clover, hairy indigo, and other tropical legumes	6.0
Cool-season legumes or legume-grass mixtures	All true clovers (white, red, arrowleaf, crimson, subterranean), vetches, lupines, and sweet clover	6.0–7.0
Alfalfa	Alfalfa	7.0

Table 2. Interpretation for bahiagrass soil and tissue test.

Soil Test	Tissue Test	Recommendations
P MEDIUM/HIGH	NO TISSUE TEST	0
P LOW	$P \geq 0.15\%$	0
P LOW	$P < 0.15\%$	25 or 40 lb. P_2O_5/acre†
† Recommended amount of P_2O_5 depends upon nitrogen option chosen.		

Tissue Analysis as a Nutrient Management Tool for Bahiagrass Pastures[1]

M. L. Silveira, J. M. Vendramini, L. E. Sollenberger, and C. L. Mackowiak[2]

Principles of Tissue Analysis

While some plant nutrient deficiencies can be easily identified based on visible symptoms, others may not produce any specific foliar symptoms other than reduced yield. In this case, plant analysis can be useful for diagnosing nutrients that are limiting optimum crop production. Although the concept of using plant analysis for nutrient diagnostics is not new, there is growing interest in using nutrient concentration in plant tissue as a tool to manage soil fertility in bahiagrass pastures in Florida. This is due in part to the inability of soil tests to accurately predict forage nutrient requirements. While soil tests typically examine nutrient levels in the upper 6 inches of the soil profile, plant analysis can integrate the nutrient pools present at the various soil depths. Because of extensive plant root systems, plant analysis is believed to better assess the overall nutrient status of forage crops and also reveal imbalances among nutrients that may affect crop production.

Plant analysis involves the determination of nutrient concentrations in a sample from a particular part or portion of a crop, at a specific time or stage of development. Since various factors can influence crop tissue concentrations, tissue tests should be used with some restraint and in conjunction with a routine soil testing program. Nutrient concentrations in the plant are not static and may vary within parts of the plant, time of the year, and among forage varieties and species. The factors that affect plant nutrient concentrations include (1) physiological maturity of the stand, (2) sampling procedure and parts of the plant that are sampled, (3) sample preparation and handling, and (4) environmental conditions, such as soil moisture and temperature. Thus, it is essential that samples are properly collected and handled prior to analysis. The interpretation of a plant analysis report requires a through understanding of the factors that may influence the test results. Therefore, great care should be taken when considering forage fertilization programs based on tissue analysis.

The basic principle involved in plant analysis interpretation is that yield will be limited at a critical nutrient concentration for each specific crop. The basic relationship between nutrient concentration and yield is shown in Figure 1. The critical level, defined as the nutrient concentration range in the plant sample below which crop yield is significantly reduced, varies among forage crops. For most forage crops, however, there is a "critical range" associated with yield reduction rather than a single value. Realistically, a number of factors may affect nutrient concentration and crop yield, which makes it impossible to define a specific optimum nutrient concentration in the plant.

The "critical range" refers to the nutrient level below which significant yield reduction is expected. Although "significant" yield reduction is open to interpretation, typically 10% is used for many crops. On the other hand, if a nutrient is either at the sufficient or high range, minimal or no yield response is expected due to fertilization.

1. This document is SL252, one of a series of the Department of Soil and Water Sciences, UF/IFAS Extension. Original publication date July 2007. Reviewed November 2019. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. M. L. Silveira, assistant professor and J. M. Vendramini, assistant professor, UF/IFAS Range Cattle Research and Education Center; L. E. Sollenberger, professor, Agronomy Department; and C. L. Mackowiak, assistant professor, UF/IFAS North Florida REC; UF/IFAS Extension, Gainesville, FL 32611.

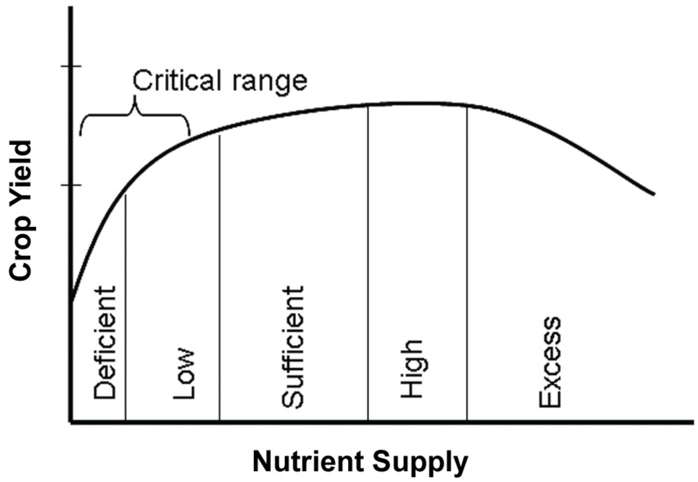


Figure 1. Relationship between nutrient supply and crop yield.

Tissue Sampling and Handling

Sample collection and preparation are important steps for ensuring accurate tissue analysis results. Similarly to soil testing, tissue samples must be representative of the field. The number of plants to sample in a specific area will depend on the general conditions of plant vigor, soil heterogeneity, and forage management. A truly representative sample should be taken by sampling a large number of plants so that the sample represents the field. Collect at least 1 ounce (30 g) of fresh material (Figure 2). Sampling is not recommended when plants are injured by insects and diseases. To avoid contamination, plants should not be sampled soon after spraying pesticides or herbicides. Care should be taken to minimize soil contamination on the sampled plant material. In addition, plants should not be sampled under temperature or moisture stress. Preferably samples should be collected during a time of the day when climatic conditions are mild, generally early to mid-morning or early evening.

Figure 2. Approximately 1 ounce (30 g or a handful) or more of leaf sample representing the field should be collected and placed in a paper bag.
Credits: UF/IFAS

The plant part, maturity stage and time of sampling are also important factors that can affect plant nutrient composition. Forage grasses and hay fields should be sampled prior to seed head emergence or at the optimum stage for forage utilization (Jones et al. 1971). As the plant matures, nutrient concentrations decline, so it is critical that plants are sampled at the proper stage of maturity. Care should be taken to select the plant part that accurately reflects the nutrient status of the plant**. The four uppermost leaf blades should be sampled** (Figure 3). Do not sample seeds since they are not useful for assessing nutrient status of forage crops and may introduce large errors in the report interpretation. If deficiency symptoms are suspected, plants showing these symptoms should be sampled and analyzed separately from "normal" or healthy appearing plants.

Figure 3. Gathering young bahiagrass leaf blades using scissors.
Credits: UF/IFAS

After sampling, tissue should be placed in properly labeled paper bags and sent immediately to a reputable laboratory for analysis. Avoid plastic bags because they can hold heat and moisture. The same precautions used for collecting the plant material should be used to handle the samples. Because fresh plant material may start decomposing shortly after collection, it is important that plant material be sent to the laboratory as quickly as possible. Prior to transporting the samples to the laboratory, plant material should be stored in a refrigerator at 41°F (or 5°C).

Tissue Analysis Interpretation

Critical concentrations of N, P, and K in bahiagrass forage are shown in Table 1. Tissue analysis has been recently incorporated into the revised UF/IFAS fertilizer recommendations as a management tool to guide proper P fertilization in established bahiagrass pastures. According to the revised UF/IFAS recommendations, tissue analysis should be performed when soil tests very low or low in

P. Assuming the soil pH is within the optimal range for bahiagrass (around 5.5) and the tissue P concentration is below the critical concentration of 0.15%, P fertilization is expected to improve bahiagrass production. Recommended P application rates vary from 25 lb P_2O_5/A for the low- and medium-N input options (50 and 100 lb N/A, respectively), up to 40 lb P_2O_5/A for the high-N option (160 lb N/A).

Table 1. Critical concentrations of N, P, and K in bahiagrass tissue.

Element	Critical concentration (%)
N	< 1.5
P	<0.15
K	<1.2

Future Directions

Similar to soil testing, plant analysis is an evolving process and our understanding needs to be updated as research results become available. Current data on critical nutrient concentration in bahiagrass should be considered preliminary and subject to modification as more science-based information becomes available. The balance among the various essential nutrients as well as the effects of bahiagrass varieties, soil characteristics, and management practices need to be fully explored in order to establish critical nutrient criteria for bahiagrass pastures in Florida. Nevertheless, from both agronomic and environmental perspectives, plant tissue analysis has potential to be a useful diagnostic tool for developing nutrient management programs that predict when crops need additional nutrients while avoiding negative impacts on the environment.

Crabgrass as a Forage and Hay Crop [1]

A. R. Blount, D. M. Ball, R. K. Sprenkel, R. O. Myer, and T. D. Hewitt[2]

Crabgrass is a high-quality summer annual forage grass that is well adapted to the sandy soils and climatic conditions of the southern Coastal Plain. While often considered a weedy species, it is a valuable temporary summer forage crop, particularly on open land planted to vegetables or row crops, and can be used in a rotation as pasture for livestock grazing or hay production.

Several species of crabgrass are found in the southern Coastal Plain. The two most widely recognized are large or hairy crabgrass (*Digitaria sanguinalis*) and the smooth crabgrass (*D. ischaemum*). Large crabgrass is the most common species that occurs naturally or intentionally planted as temporary pasture. It appears similar in size and flowering to bermudagrass, but the flowering culm, or tiller, is slender and rises separately from the stalk. The flowers are held in 3–7 slender fingerlike branches on the end of the flowering stem, which is how it received its common name, digitgrass. In comparison, bermudagrass may have several flowers on the same tiller, often called a runner. The large crabgrass seedling is usually pale green and has wide leaves covered in coarse hairs. The young leaves of crabgrass unroll as they grow out from the center of the plant. Large crabgrass also has a membranous ligule that is stiff and papery, and there are no auricles. There may be stiff white hairs located along the leaf edges, but there are no hairs found on the ligule. Large crabgrass is a clump grass and may grow up to 2 ft (60 cm) tall.

The other common species is smooth crabgrass. It is easily distinguished from the large-type crabgrass because of its short, wider leaf, blackish-brown bract and lack of noticeable hairs. Smooth crabgrass is generally considered a weed problem in turfgrass and has little forage potential. For the purpose of this article, the discussion will be limited to information concerning large crabgrass as a forage and hay crop.

Crabgrass is an annual grass, and reseeds itself year after year, if it is managed to allow the plant to flower and produce seed during the previous season. Crabgrass forage has excellent quality and palatability, but yield is variable and depends on soil fertility and rainfall. The forage quality of crabgrass is typically better than most other summer grasses. For example, crabgrass hay is usually higher quality than hay of bermudagrass, bahiagrass, or more commonly planted summer annual grasses such as pearl millet or sorghum-sudan hybrids. In grazing tests with yearlings in Oklahoma, average daily gains on crabgrass averaged more than 1.4 lb; by comparison, average daily gains (ADGs) on bermudagrass or bahiagrass are typically around 1.0–2.0 lb. In trials with stockers in North Florida, ADGs of 1.1–1.9 lb/day were obtained when grazing crabgrass. Dry matter

1. This document is SS-AGR-193, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date August 2003. Revised August 2006 and September 2013. Reviewed January 2017. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. A. R. Blount, professor, Agronomy Department, UF/IFAS North Florida Research and Education Center; D. M. Ball, emeritus extension forage crops agronomist, Auburn University, Auburn, GA; R. K. Sprenkel, emeritus professor, Department of Entomology and Nematology, UF/IFAS NFREC; R. O. Myer, emeritus professor, Animal Sciences Department, UF/IFAS NFREC; and T. D. Hewitt, emeritus professor, Food and Resource Economics Department, UF/IFAS NFREC; UF/IFAS Extension, Gainesville, FL 32611.

Reviewed: 02/2022

forage yields can range from only 1 to more than 5 tons/acre, typically dry matter ranges from 3 to 5 tons/acre.

Where Crabgrass Fits in a Forage System

Crabgrass is adapted to many soil types, but grows best on well-drained soils, especially sandy loam, sandy clay loam, or clay loam soils. Volunteer stands of crabgrass are common in pastures that are newly established with a perennial summer forage or often fill in gaps in established perennial forage stands.

Planting crabgrass fits well in open land situations where planting annual winter forages, such as ryegrass, oats, rye, or wheat, for early grazing is the goal. The periods for winter annuals and crabgrass are complementary and allow for slight overlap in seasonal forage production. Shallow tillage prior to planting winter annuals will incorporate crabgrass seed and usually results in good crabgrass stands the following spring, without the need for spring tillage. However, to ensure early spring growth of crabgrass, a producer can shallowly disk the winter annual forage (about 3 inches deep) once production has declined significantly in spring and a new crabgrass stand will normally appear, assuming there is an ample quantity of crabgrass seed in the soil. When the crabgrass stand is established, fertilization is the primary management practice required. Crabgrass growth declines by late August or early September.

Establishment and Management

Establish crabgrass on well-drained land that has been limed. Crabgrass is very tolerant of pH and grows under a wide range of soil pH levels from 5.5 to 7.5. Crabgrass should be planted on a clean, fresh seedbed in spring after the danger of frost is past. The seedbed should be firm, preferably cultipacked, so that seed is not planted below 1/2 inch. Seed can be drilled about 1/4-inch deep or be broadcast over the soil surface. It may be helpful to use a cultipacker after seed have been broadcast, as this gives better seed-to-soil contact and may avoid washing of seed by a heavy rain.

Good stands have been obtained with as little as 2 lb of pure live seed (PLS) per acre, but planting 3–5 lb PLS per acre helps ensure quick cover and a thick, productive stand. The seed can be mixed with a small quantity of a low analysis starter fertilizer (nitrogen-phosphorus-potassium) if planted promptly after the seed and fertilizer have been mixed. Such a mixture of seed and fertilizer broadcasts or flows through a drill better than crabgrass seed alone.

If adequate moisture is present, some crabgrass seed will germinate within a few days, though the stand may continue to thicken over a period of 2 months or more from additional seedling establishment resulting from slower-germinating seed. It is not unusual for a crabgrass stand to be 6 inches high and suitable for grazing within 30 days.

Topdressing with additional N can be done after the grass has emerged and seedlings are in the early tiller stage. A total season application of at least 120 pounds of N per acre in split applications is recommended. Split applications of N might be necessary if the crabgrass stand is established early. Season-long applications up to 200 lb N may be justified to achieve maximum forage yields. Nitrogen applications after mid-August are probably **not** justified.

Crabgrass germination begins when soil temperature is around 58°F. Disking a field to encourage volunteer crabgrass may be most appropriate in mid-spring in a field where winter annuals are being grown. Where there are no winter annual forages to be concerned about, it is best to disk the field in late February or early March. This allows crabgrass to get an earlier start and thus make more total forage growth.

If it is not necessary to till a crabgrass field in late summer or early autumn in order to plant winter annuals, there will continue to be some crabgrass growth until a killing frost occurs. However, late summer/autumn production is low and the forage is lower in quality and should be used by animals that have relatively low nutritional requirements. This is an ideal time to remove livestock to allow the crabgrass to reseed itself.

Crabgrass for Grazing

Because crabgrass is quite tolerant of defoliation, it can be grazed or cut as low as 3 inches. If rotationally stocked, it is best to begin grazing when pastures are no more than 12 inches high, rotate animals off when they are between 3 and 6 inches high, and restock when they are 6–8 inches high. In Noble Foundation tests with yearlings, stocking rates have generally been 1,000–1,100 lb of calf per acre and the length of the grazing season has varied from 60 to 120 days.

Crabgrass Hay

Crabgrass should be cut for hay in the boot to heading stage (normally 18–24 inches high), which should allow at least two harvests per year. When regrowth is desired and accumulated crabgrass forage is tall, cutting height may need to be more than 3 inches because some green leaf tissue should be left to favor quick regrowth. If crabgrass is cut before it makes mature seed, leave 6-inch uncut strips between mower swaths, as this is one way to produce enough seed for reseeding. If crabgrass makes mature seed before being cut for hay, forage quality will be lower.

Other things being equal, the first harvest of the year will result in the best hay, sometimes containing more than 15% crude protein and 60% total digestible nutrients (TDN). Crabgrass hay normally cures more slowly than bermudagrass, but more quickly than sorghum-sudan hybrids or pearl millet. Crabgrass hay is dark in color and may appear to have a lower quality than what a quality analysis would indicate.

Insect Pests

Because of limited plantings of crabgrass as a pasture and hay crop in the Southeast, the crop is relatively free of serious insect pests. However, past experience with other crops has shown that the potential of pest species may not be realized until a substantial acreage has been planted, which enables a host preference and adaptation to occur. Of the likely insect pests, grasshoppers, fall armyworm, and perhaps the southern chinch bug pose the greatest threat.

Several species of grasshoppers are found throughout the Southeast that may defoliate large crabgrass. One of the most common is the American grasshopper. Eggs are laid in clusters beneath the soil surface. The eggs hatch throughout the summer, and the green nymphs are capable of defoliating hay fields in a short period of time. Large populations may be present on ditch banks and in weedy areas in the vicinity of hay fields. If these areas are mowed or treated with an herbicide, movement of the grasshoppers to the hay field can result in considerable defoliation.

Even if acreage of crabgrass increased greatly, it is likely that the fall armyworm would be only an occasional pest of crabgrass in the Southeast. The fall armyworm prefers bermudagrass as a host. However, during outbreak years (every 3–5 years) nearly all forage grasses are damaged, including large crabgrass. The fall armyworm survives the winter in Central and South Florida. Early each spring the strong-flying moths reinvade North Florida and adjacent areas of the Southeast. Each female moth is capable of laying 100 or more eggs during her two-week life span. Larval development requires 12–16 days to complete, and fully grown larvae are approximately 1½ inches in length. When feeding on grasses such as crabgrass, the fall armyworm spends a considerable portion of the day on the soil or in trash at the soil line. Most of the feeding occurs late in the day, at night, and early in the morning. There may be up to six generations per year in North Florida. Most of the damage to forage grasses occurs during September when annual populations of the fall armyworm in the Southeast are typically the highest.

Chinch bugs damage grasses by sucking plant juices. They favor dry weather and tend to prefer thin stands. The adult chinch bug is 1/3-inch-long with a black body. It has white wing covers, each with a black triangle at the middle of its outer margin. The chinch bug nymph is reddish with a white band across its back. An older nymph is reddish-brown with a white band. Eggs are white when first laid but turn bright orange just before hatching. Severe damage to crabgrass is not likely because the chinch bug prefers more succulent hosts.

There have not been a sufficient number of studies or observations to suggest treatment thresholds for these pests. Therefore, growers are advised to monitor the crabgrass stand frequently for the presence of insect pests. If pests are present and damage appears to be excessive, treatment is probably warranted.

Grasshoppers may be controlled using Malathion 57EC at the rate of 1½–2 pints per acre. There are no restrictions on the number of days to harvest or grazing. The Sevin 4F (carbaryl) label allows for the application to rangeland for the control of grasshoppers at the rate of ½–1 quart per acre. There are no restrictions on the number of days to harvest or grazing. However, a maximum of one quart may be applied per season.

Malathion 57EC at the rate of 2 pints per acre or Sevin 4F at the rate of 1–1½ quarts per acre may be used to control fall armyworms. It is important to time the treatments to small worms (< 3/8 inch in length) to obtain acceptable control. There is a 14-day waiting period at this application rate between treatment with Sevin and harvest or grazing.

Chinch bugs may be controlled using Sevin 4F at the rate of 1–1½ quarts per acre.

Other pesticides may be used to control insect pests on crabgrass. Application rates and harvest or grazing restrictions of these products will be located on the labels.

Disease Problems

No major disease problems on crabgrass used for forage in Florida have been reported. Because crabgrass is often used as a naturally seeded temporary pasture forage, livestock producers may not notice disease problems. The foliage is often used quickly by livestock in situations when a new permanent summer pasture is establishing. Because crabgrass is an opportunistic pasture species that grows as a companion plant to bahiagrass or bermudagrass, little attention is generally given to disease problems with the plant. In other circumstances, where crabgrass occurs in open fields that had been seeded to winter annual forages or open crop land that is fallowed the following spring, livestock producers often view this as a free forage crop and may not notice diseases occurring on the plant.

There are several diseases that do occur on crabgrass in Florida and these include: *Alternaria* sp. leaf spot, *Curvularia geniculata* leaf mold, *Drechslera gigantea* leaf spot, *Bipolaris* (*Helminthosporium* sp.) leaf spot, *Puccinia oahuensis* rust, *Rhizoctonia solani* root rot, *Sphacelotheca diplospora* head smut, *Ustilago syntherismae* loose smut, and sugarcane mosaic virus. These diseases, which can lower forage yield, are favored by climatic conditions in some years. There are no chemical control options.

Available Seed

Crabgrass seed will probably have to be special ordered, but it is not difficult to obtain from seed suppliers. However, there is a great deal of genetic diversity within crabgrass, and you cannot be certain what you are getting if you purchase "common" crabgrass seed.

The Noble Foundation in Ardmore, Oklahoma, released two crabgrass varieties, Red River and Quick and Big. Because these varieties are known to be productive from the standpoint of dry matter yield, they are currently the recommended crabgrass varieties for Georgia, Alabama, and Florida.

Summary

The benefits of common and improved crabgrass in a livestock enterprise are great, as it is a highly palatable and relatively inexpensive annual forage grass. Livestock producers have used crabgrass in many annual forage programs, as well as in situations in which it has volunteered in the establishment of permanent pastures. While crabgrass is a weed in many horticultural and row crops, it is actually a good quality summer annual grass that has a place in forage systems throughout the southern Coastal Plain.

SS-AGR-89

UF | UNIVERSITY of FLORIDA
IFAS Extension

Producing Millets and Sorghums[1]

C. G. Chambliss and M. B. Adjei [2]

Pearl millet (*Pennisetum americanum*) (Figure 1) and **sorghum-sudan hybrids** (*Sorghum x drummondii*) (Figure 2), are warm-season, rapidly growing, high-yielding, high-quality, annual grasses. They are often planted following small grains, a spring vegetable crop, or some other cultivated crop. Occasionally they may be planted in a pasture renovation program, where the perennial grass is destroyed and the area is planted with the annual grass. These annual grasses are usually grazed by animals that need a high-quality forage, such as stockers, replacement heifers, first-calf heifers, or dairy cows. Pearl millet and sorghum-sudan hybrids are excellent creep pasture for nursing calves and may be harvested as hay, green chop, or silage. Making hay is usually difficult because of the large stems. A hay conditioner is needed, and extra drying days are required compared to making hay with bermudagrass.

Pearl millet is leafy, with an upright growth habit, and grows 4 to 8 feet tall. It can be grown throughout the state on well-drained soils but does not perform well on calcareous soils or on flatwood sites

Figure 1. Pearl millet - flowering stage.

that flood. Sorghum-sudan hybrids, although not particularly tolerant of flooded soils, may be the better choice for use on the wetter sites. Pearl millet is tolerant of drought and acidic soil conditions. The dwarf or semidwarf types such as Tifleaf I, II, and III are more leafy, with less stem than the taller types, and therefore may be easier to manage under grazing. The taller types may produce more forage dry matter

1. This document is SS-AGR-89, one of a series of the Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. First published June 2002. Revised February 2006. This publication is also a part of the Florida Forage Handbook, an electronic publication of the Agronomy Department. For more information you may contact M.B. Adjei (mba@ufl.edu). Please visit the EDIS Web site at http://edis.ifas.ufl.edu.
2. C. G. Chambliss (deceased), associate professor, Agronomy Department; M. B. Adjei, associate professor, Agronomy Department, Range Cattle Research and Education Center--Ona, FL; Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

Figure 2. Sorghum-sudan, seedhead.

per acre than the dwarf types, but animal production is usually the same. Leaf numbers are usually the same for short and tall types; the differences in total height being due to longer internodes ("distance between the joints") for the taller types.

Pearl millet can be planted from mid-March through June in south Florida. The earliest planting date in north Florida should be around April 1. Soil temperature must be warm before planting since seed germination and seedling growth are very sensitive to cool soil conditions. A late summer planting could be made in south Florida or midsummer in north Florida for a single fall grazing or harvest. Regrowth from late plantings is less than from earlier plantings. Both pearl millet and sorghum-sudan hybrids can be broadcast, drilled, or planted in rows. The seeding rate for broadcast plantings is 24 to 30 pounds per acre. The seeding rate can be reduced for drilled and row plantings. A low seeding rate or poor stand may not be a disaster since many varieties have excellent tillering capability and can fill in voids. With the early planting dates, the bulk of the forage is produced from June through August.

Producers should be prepared to graze pearl millet rotationally. Millet should reach a height of 14 to 24 inches before each grazing period. Try to graze each pasture down to 6 to 8 inches in one to three days. After a pasture has been grazed, allow it to regrow to a 14 to 24 inch height before regrazing. When plants start to form heads, removing heads by mowing may prolong vegetative growth. If harvested for hay, cut when plants are approximately 3 feet high and use a hay conditioner to crush the stems. Harvest for silage in the boot to early-head stage of growth, and if possible, allow to wilt before chopping.

Both pearl millet and sorghum-sudan hybrids can be grown on low-fertility soils that are moderately acidic. The recommended soil pH for these grasses is 6.0. Apply 30 lb of N per acre, 50 percent of the soil-test recommended K_2O, and all of the P_2O_5 in a preplant or at-planting application. Apply 50 lb N per acre and the remaining K_2O after the first grazing period. Apply an additional 50 lb N per acre after each grazing period or harvest as needed.

One important difference between pearl millet and the sorghum-sudan hybrids is that the sorghum-sudan hybrids contain a compound called dhurrin which can break down to release prussic-acid (HCN) and cause poisoning in cattle. Sudangrass has low levels of this compound, sorghum-sudan has intermediate levels and sorghum has the highest level.. Prussic acid tends to be high in young seedlings and young regrowth. It may be high in both old and young growth when plants are frosted. Therefore, cattle should not be allowed to graze sorghum-sudan hybrids until the plants are 24 inches tall, whether initial growth or regrowth. Also, cattle should be removed from sorghum-sudan fields when frost is likely to occur. After the frosted plants have dried, which may take 7 to 10 days, they are safe to graze. Prussic acid is not a problem in hay or silage. However, because of the warmer temperatures in south Florida, new tillers may form at the base of frosted plants and this new growth will be high in HCN and will likely be toxic. Remember that these young plants are high in prussic acid and should not be grazed. Also don't green chop forage, leave in a wagon overnight and then feed the next day. The heat that occurs in the green chop will release prussic acid and increase the likelihood of toxicity in the feed. Both pearl millet and the sorghum-sudan hybrids can accumulate nitrates during a drought if nitrogen is applied just prior to the beginning of the drought. Animals consuming forage high in nitrates may die from "nitrate poisoning." Horses should not be allowed to graze or consume hay made from sorghum-sudan hybrids since this may cause a health problem called cystitis syndrome, which is inflammation of the urinary tract.

Cultivars of Millets

Pearl millet, Tifleaf I, II, and III are all (*Pennisetum americanum)*

Japanese millet (*Echinochloa crus-galli* var. *frumentacea*) grows 2 to 4 feet tall. It should not be confused with pearl millet. It matures quickly, and thus its forage yield is much less than that of pearl millet. A named variety, Chawapa, grows taller and produces more forage than the common japanese millet. Japanese millet is sometimes seeded with a new planting of bahiagrass to furnish an early grazing or seed crop. Be careful to not let the millet shade out the bahiagrass seedlings. Japanese millet is also planted for wildlife feed and for temporary soil stabilization on construction sites.

Browntop millet (*Panicum ramosum*) is similar to japanese millet in growth habit and use. It is an excellent seed producer and is often planted to provide feed for mourning doves and other game birds.

Prosso millet (*Panicum miliaceum)* is a bit more cold tolerant than browntop millet but has similar uses.

Cultivars of Sorghums

Grain sorghums are short in height (3-5 ft) and are not normally considered for forage because of low dry matter yield. Forage sorghums can grow tall (8-13 ft), have bigger stems and produce a lot of dry matter tonnage. They are difficult to dry because of their large stems. Sorghum- sudan hybrids are intermediate in height (4-7 ft), have smaller stems and dry faster

Tall forage sorghums are used for silage (Sorghum bicolor) have large-diameter stems and may grow 8 to 10 feet tall. They are grown almost entirely for use as silage. These hybrids may produce as much grain as the combine-type grain sorghums. Therefore, the difference between the two types is mainly in the amount of stalk produced. The shorter-growing grain sorghums produce a higher-quality or higher-energy silage than the tall types, but the total forage yield is only 1/2 to 1/3 that of the tall types. The crop should be harvested for silage when the grain is in the milk to soft-dough stage. Delay of harvest beyond this stage results in serious loss of forage quality. Sorghum silage is less digestible and less palatable than corn silage. Genetic engineering has enabled the creation of a new generation of Brown Midrib (BMR) forage sorghums that have significantly lower stem lignin concentration and a much improved digestibility equal to that of corn. The BMR 106, which has 40% more digestibility over conventional forage sorghums, is a good example of this new technology.

Sudangrass (*Sorghum x drummondii*) is similar to the sorghum-sudan hybrids but is shorter and has finer stems. Yields are lower than the sorghum-sudan hybrids. Production, management, and utilization practices are the same as for sorghum-sudan hybrids.

Sorghum-sudan hybrids are similar to pearl millet in growth habit, season of production, use, and recommended management practices, but they differ in some ways. Many hybrids produced by private seed companies are available for planting. Select a hybrid that is adapted to your area, has good disease and insect resistance, and tillering capability. Some of the large-stem types do not tiller as well as those with smaller stems. Among the new generation sorghum-sudan hybrids with improved forage digestibility are BMR 1000 hybrid forage, BMR 2001 and BMR 3001 sorghum Sudan grasses.

Crabgrass (*Digitaria sanguinalis*) is a fine-stemmed annual grass that has been used for both hay and grazing. Crabgrass can be found volunteering throughout the state and has been successfully planted on some of the heavier soils of northwest Florida. It is most often seen as a weed during the establishment of bermudagrass hay fields. It is adapted to fertile soils that have good surface drainage. Crabgrass is a relative of Pangola digitgrass, but unlike Pangola it can be established from seed. Crabgrass is a reseeding annual and can re-establish itself in the spring if allowed to make seed in the previous growing season. Like Pangola, crabgrass is very palatable and usually more digestible than bahiagrass or bermudagrass. When volunteer stands develop, a producer may fertilize the grass the same as bermudagrass and cut it for hay or graze it.

What is 4R nutrient stewardship?[1]

Guodong Liu, Kelly Morgan, Yuncong Li, Lincoln Zotarelli, Qingren Wang, and James DeValerio[2]

Introduction

This EDIS publication is the first in a series on understanding the four RIGHT (4R) nutrient stewardship applications for crop production. There is a fact sheet, SL411, introducing the details of the 4Rs (http://edis.ifas.ufl.edu/ss624). This fact sheet focuses on the scientific principles, importance, and assessment of the 4Rs. It also emphasizes the relationship among the 4Rs and who decides what is correct in the 4Rs.

Fertilizers play an essential role in Florida's commercial crop production and in food security nationally and worldwide. Fertilizers provide nutrients essential for crop production but also pose pollution risks to the environment, which can constrain both the economy and society. To control water pollution caused by fertilizers, best management practices (BMPs) were first defined by the U.S. Environmental Protection Agency (EPA) in the federal wastewater permit regulation in 1977. BMPs are defined as "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States" that "also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage" (EPA 2015b). To ensure the environmental, social, and economical sustainability of commercial crop production, an overview of a new and innovative approach to BMPs for fertilizer application known as 4R nutrient stewardship is available to environmentalists, Extension agents, crop consultants and advisors, growers, and graduate students who are interested in agriculture.

What does 4R nutrient stewardship mean?

For any commercial crop production, the quality of nutrient management practices is determined by the 4Rs. The 4R nutrient stewardship concept is defined as

- the RIGHT fertilizer source is applied at
- the RIGHT rate at
- the RIGHT time, and in
- the RIGHT place for a crop.

This simple management concept can help growers implement appropriate management practices for fertilizer application to enhance the sustainability of agriculture. All of those involved in crop production, including growers, crop consultants and advisors, extension faculty, research scientists, policymakers, consumers, and the public, must participate in advancing the goals of the 4R program.

1. This document is HS1264, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date July 2015. Revised January 2019. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Guodong Liu, associate professor, Horticultural Sciences Department; Kelly Morgan, professor, Department of Soil and Water Sciences, Southwest Florida Research and Education Center; Yuncong Li, professor, Tropical REC; Lincoln Zotarelli, associate professor, Horticultural Sciences Department; James DeValerio, former Extension agent II, UF/IFAS Extension Bradford County; and Qingren Wang, Extension agent II, UF/IFAS Extension Miami-Dade County; UF/IFAS Extension, Gainesville, FL 32611.

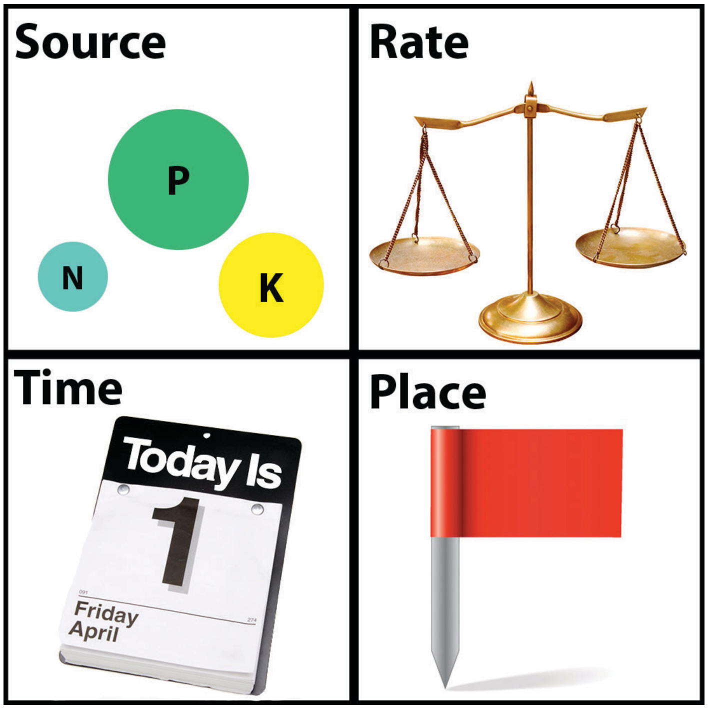


Figure 1. Schematic diagram of the 4Rs.
Credits: Rate: suriyasilsaksom/iStock/thinkstock.com; Time: Creatas Images/Creatas/thinkstock.com; Place: rashadashurov/iStock/Thinkstock.com

Why is 4R nutrient stewardship so important?

The 4R nutrient stewardship is important because there are many sustainability issues related to fertilizer and nutrient management in commercial crop production such as

- food security and safety,
- soil health, fertility, and quality,
- non-renewable resources,
- eutrophication (nitrate, phosphate, algae bloom pollution) and water quality,
- air quality (ammonia volatilization),
- greenhouse gas emission (carbon dioxide (CO_2) and nitrous oxide (N_2O)),
- stratospheric ozone depletion caused by N_2O, and
- heavy metal pollution in soil (cadmium).

Each of the items on the above list is closely associated with human wellness and quality of life.

Are the 4Rs interdependent or independent?

The four facets of nutrient management practices are fully interdependent and linked in the cropping system.

- The 4Rs of nutrient management—source, rate, time, and placement—are fully linked and interconnected to every step of management practice for every farming system.
- No one of the 4Rs can be right when any of the 4Rs is wrong.
- The 4Rs must work in sync with each other and with the environment.
- The combination of the 4Rs changes with the farming system.
- The combination of the 4Rs changes with local water quality issues.

What are the scientific principles for 4R nutrient stewardship?

The fundamental scientific principles are the basis of the 4R nutrient stewardship because the basic sciences are fundamental to the growth and development of plants grown on soils.

- The sciences applied to the 4Rs include biology, chemistry, physics, etc.
- Applying scientific principles to managing plant nutrients tests the scientific principles of plant nutrition.
- Scientific principles help guide the development of practices that determine the 4Rs.
- The principles are the same worldwide, but actual practices are crop and site-specific.

How should we assess implementing 4R nutrient stewardship?

The goals of 4R nutrient stewardship are to enhance the economic, environmental, and social sustainability of the cropping system. All the indicators related to the economy, environment, and society should be assessed (Table 1).

Table 1.

Crop yield	Profitability
Yield stability	Soil productivity
Product quality	Soil quality
Nutrient use efficiency of all applied fertilizers	Water quality
Water use efficiency	Air quality
Energy use efficiency	Biodiversity
Labor use efficiency	Farm income
	Nutrient budget

Who decides what is right in the 4Rs?

All participants decide the 4Rs. Participants include

- Growers.
- Scientists.
- Extension faculty.
- Crop consultants and advisors.
- Environmentalists.
- Agribusiness professionals.
- Stakeholders.

Everything from crop selection to market choice and consumption are factors that will determine what set of nutrient management practices are correct.

Summary

- The 4R nutrient stewardship includes the right fertilizer source applied at the right rate, the right time, and the right place for a crop producing sustainable economic, social, and environmental outcomes.
- The 4Rs are all interdependent and interconnected.
- The 4Rs play irreplaceable roles in sustainability of the economy, society, and environment.
- The 4R nutrient stewardship is guided by biology, chemistry, and physics.
- The 4R nutrient stewardship is an essential tool for commercial crop production BMPs.
- The performance measures and indicators include use efficiencies of fertilizers, water, energy, and labor, crop yield and yield stability, soil productivity, profitability, etc.
- All stakeholders of commercial crop production decide what counts as "right" in the 4Rs.

References and Further Reading

Bruulsema, T., J. Lemunyon, and B. Herz. 2009. "Know your fertilizer rights." *Crops & Soils* March–April 2009: 13-18. http://www.ipni.net/ipniweb/portal/4r.nsf/0/1748D80FEC9FE7C185257DF10074A028/$FILE/Know%20Your%20Fertilizer%20Rights.pdf (Accessed January 2019)

Federal Water Pollution Control Act (Clean Water Act). 2002. 33 U. S. C. § 1251 et seq. http://www.epw.senate.gov/water.pdf (Accessed July 6, 2015)

Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. *The Four Rs of Fertilizer Management*. SL411. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss624 (Accessed January 2019)

Mikkelsen, R. L. 2011. "The '4R' Nutrient Stewardship Framework for Horticulture." *HortTechnology* 21(6): 658–662.

US Environmental Protection Agency (EPA). 2015a. "Summary of the Clean Water Act." http://www2.epa.gov/laws-regulations/summary-clean-water-act (Accessed January 2019)

EPA. 2015b. "Title 40, Subpart 122.2: Definitions" in *Electronic Code of Federal Regulations*. Washington, DC: U.S. Government Publishing Office. http://www.ecfr.gov/cgi-bin/text-idx?SID=9be8514046d3f051480db50d6c4f7548&mc=true&node=pt40.22.122&rgn=div5#se40.22.122_12 (Accessed January 2019)

SL411

The Four Rs of Fertilizer Management[1]

George Hochmuth, Rao Mylavarapu, and Ed Hanlon[2]

Fertilizers or nutrients are required in most crop production systems in Florida. While all soils in Florida can supply nutrients for crop production, nutrients may not be always available in adequate amounts for economical crop production. Supplying needed nutrients for crop production involves attention to four major fertilization factors (the 4Rs): *right rate*, *right source*, *right placement*, and *right timing*. Attention to these factors will provide adequate nutrition for crop production while minimizing the risk of loss of nutrients to the environment. The 4Rs (terminology promoted by the International Plant Nutrition Institute [2014]) are important components of nutrient best management practices, and university Extension specialists have been promoting these components of nutrient management for many decades. In this publication each factor is described, as well as how the information can be provided from a soil test report to help farmers make efficient use of their investment in fertilizer for crop production and for environmental protection. These factors are often interrelated; for example, placement and timing of fertilizer may need to be addressed together, such as the right placement of bands of fertilizer for side-dressing during the appropriate stage (i.e., right timing) of crop growth during the growing season. While not a formal part of the 4Rs, the importance of irrigation to overall nutrient management is stressed in this publication.

Right Source

Selecting the *right source* of fertilizer or the right material to deliver the nutrients is important. The right source can be related to the following questions:

- What source of nutrient(s) would be the least expensive per unit of delivered nutrient?
- Should an organic source (compost or manure) of nutrient be considered?
- When is a controlled-release fertilizer the right source?
- What sources can simultaneously deliver more than one needed nutrient?
- When should a liquid form be used instead of a dry form?
- When should the salt index of the fertilizer be considered in selecting the right source?

The right source often involves the ease of application of a nutrient and cost per unit of nutrient. In addition, efficiency of nutrient use may be considered. For example, a controlled-release nitrogen source may be preferred to deliver small amounts of nutrients throughout the growing season, instead of larger amounts of nitrogen delivered in a few side-dressings from a soluble source.

The right source may be manure, if the farmer would like to take advantage of the organic matter supplied along with the plant nutrients. The organic matter may increase the water-holding capacity and nutrient supply of the soil.

1. This document is SL411, one of a series of the Department of Soil and Water Sciences, UF/IFAS Extension. Original publication date June 2014. Revised April 2022. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. George Hochmuth, professor emeritus; Rao Mylavarapu, professor; and Ed Hanlon, professor emeritus; Department of Soil and Water Sciences, UF/IFAS Extension, Gainesville, FL 32611.

Right Rate

Crops require a certain amount of plant nutrients for production of profitable crops. Part of this nutrient quantity can be supplied from the soil, and the remainder must come from fertilizer, either synthetic sources or organic forms (such as livestock wastes composts) or green manure crops. The first key to practicing the *right rate* concept is soil testing (see EDIS publication SS621, *Soil Testing for Plant-Available Nutrients—What Is It and Why Do We Use It*?). Before the crop is planted and any fertilizer has been applied, soil testing can help determine the portion of the crop nutrient requirement that is already available from the soil. Using a strong research information base, the recommendation for the right rate of fertilizer can be made from the soil test result.

The *right rate* refers to the amount of fertilizer needed for the crop production season and is based on extensive research over locations, crops, varieties, and years. The right rate also refers to the amount of fertilizer applied at one time in the growing season. For example, the farmer needs to know, depending on the cropping system used, the right rate of fertilizer to apply in the following scenarios:

- In the preplant application, while the mulched bed is made for plasticulture vegetables
- As a starter fertilizer for direct-seeded crops like potato, corn, or cotton
- As the amount to inject (fertigation) into the drip irrigation system at any one time
- In a single side-dressing during the growing season for an unmulched crop
- In a single fertigation through the center-pivot irrigation system

Sometimes the right rate to apply at any one time is related to the nutrient involved. For example, in plasticulture vegetables, all of the phosphorus may be applied to the soil while the bed is made. Likewise, a portion of the nitrogen and potassium may be applied while the bed is being made and the remainder applied through the drip irrigation system.

Right Timing

The *right timing* of nutrients takes into consideration the growth pattern of the crop and, therefore, natural changes in nutrient demand during the season. Crop development begins slowing from seed germination or transplanting, then increases through fruiting, and finally slows down at maturation. This pattern for crop development is referred to as *sigmoidal* growth (Figure 1). Anticipating changes in growth and nutrient demand is important so that fertilizer application can be timed to meet the needs of growth. A good example of timing of nitrogen and potassium fertilization to meet changes in crop development can be seen for drip-irrigated tomato (Figure 2).

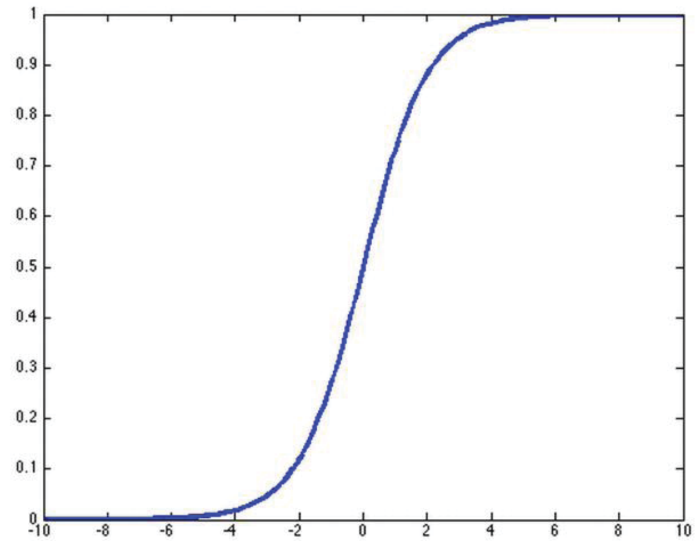


Figure 1. A sigmoidal function—for example, slow crop growth at first, then a zone of rapid increase, followed by attenuation of growth.

Period in the season	Amounts of N and K (K_2O)
Preplant	0 to 70 lb per acre
Weeks 1–2	1.5 lb/acre/day
Weeks 3–4	2.0 lb/acre/day
Weeks 5–11	2.5 lb/acre/day
Week 12	2.0 lb/acre/day
Week 13	1.5 lb/acre/day

Figure 2. Recommendations for injecting N and K_2O for mulched, drip-irrigated tomatoes in Florida. The amounts for injection in this table assume zero preplant N or K_2O. These recommended amounts should be adjusted for any preplant fertilizer, for example, omitting the first week or two of injections.

The right timing is often interrelated with the right rate and right placement. For example, as the drip-irrigated tomato crop develops, the rate changes with time so that smaller rates are applied later in the growing season. Greater rates of nutrients are applied at or just before the time when the vegetative growth rate is maximal and fruits are being developed.

Rainfall is difficult to predict; however, when possible, fertilizer application should be timed to minimize the chance of leaching of nutrients due to heavy rainfall.

Right Placement

For maximum nutrient efficiency, nutrients need to be placed where the plant will have the best access to the nutrients. For most crops, the *right placement* is in the root zone or just ahead of the advancing root system. Most nutrient uptake occurs through the root system, so placing the nutrients in the root zone maximizes the likelihood of absorption by the plant.

Banding and broadcasting are two general approaches to nutrient placement. *Banding* is the placement of fertilizer in concentrated streams or bands in the soil, typically near the developing plant. *Broadcasting* is the spreading of fertilizer uniformly over the surface of the soil. Whether to use banding or broadcasting often depends on the type of crop and the development or spread of the root system. Broadcasting is usually most effective either later in the season when roots of a row-crop have explored the space between the rows, or for forage crops that cover the entire soil surface. Fertigation of nitrogen through a center-pivot irrigation system for corn may be a type of fertilizer broadcasting system.

Placement and timing interact because as the crop develops, the root system expands. Placement of fertilizer ahead of the advancing root system for unmulched crops, like potato or cotton, avoids damage to the root system by the fertilizer application equipment. Another example of this interaction would be for fertigation with a pivot irrigation system. The first side-dressings of nitrogen early in the growth cycle for corn may be applied by knifing liquid fertilizer to the side of the row, followed later in the season with applications through the irrigation system. These combinations of timing and placement maximize the likelihood of nitrogen uptake by the plant related to the expansion of the root system.

The tillage system may affect the placement of nutrients. For example, incorporating a nutrient may not be possible in certain minimum tillage systems. In no-till corn production, early nitrogen and phosphorus applications can be made by banding near the seeds with the planter, with later applications of nitrogen by the center-pivot irrigation system.

The right placement is also related to the nutrient in question. For example, phosphorus can become fixed in unavailable forms when it is mixed in with some soils. The main reason P is banded is that it is immobile in the soils and therefore has to be placed nearer to the roots (or the roots have to grow towards the P granule). In sandy loams, P applied to the surface will get adsorbed and can accumulate over time. Accumulations also occur in soils applied with P sourced from organic or manure related amendments. In these situations, banding of the fertilizer reduces, at least temporarily, the mixing of the fertilizer with the soil and increases the chance that phosphorus will remain in a soluble form for root uptake. For example, banding starter-phosphorus may be preferable to broadcasting.

The right placement may also relate to the form of the nutrient source, such as urea nitrogen. Nitrogen from urea may be subject to loss by volatilization when the urea is left on the surface of soil with a high pH. Incorporating the urea or applying a small amount of irrigation to move the urea into the soil helps reduce volatilization losses.

In certain situations and for certain nutrients, foliar applications of fertilizer may be preferred. For example, micronutrients may be more efficiently applied to the foliage for iron or manganese when the soil pH is high.

Integrated Approach

All nutrient management practices are the result of many years of research and field experience at the commercial farm level (Table 1), and these practices are subject to refinement as farmers gain experience and as new research is completed. Optimal nutrient management rarely relies on a single practice, but rather a combination of practices. Selecting the best combination is the goal of all nutrient management that addresses profitable crop production while protecting the environment from nutrient loss.

Importance of Irrigation Management

In the sandy soils of Florida, there is a fifth R: *right irrigation practices*. Mobile nutrients such as nitrogen and potassium can be leached with the water moving through the soil in the root zone. Excessive irrigation, or irrigation when the soil water-holding capacity is full, will cause nutrients to be leached below the root zone. Farmers should track soil moisture, because coupling knowledge about soil moisture status with crop water requirements is the best way to maximize water-use efficiency and minimize nutrient leaching. UF/IFAS Extension recommends applying 30 lb/acre N after a leaching rainfall of 3 inches in four days or 4 inches in seven days.

In areas where fertigation is possible, the optimal rate, timing, and placement of nutrients can be collectively achieved, especially for N and K. When using fertigation, efficiency in application of fertilizer and irrigation water can be significantly increased, and environmental losses from the production systems can be minimized.

Summary

The concept of the 4Rs is important for maximizing fertilizer-use efficiency, promoting profitable crop production, and protecting the environment from pollution due to losses of nutrients from agricultural land. Selecting the right fertilizer rate, right fertilizer source, right fertilizer placement, and right fertilizer timing are important aspects of best management practices. Farmers should consider all the options for each "right" component and select the best combinations for maximizing crop profitability and minimizing negative environmental impacts.

Growers and crop educators and advisors should constantly measure fertilizer use efficiency associated with the 4Rs and make adjustments to improve efficiency. An example of how to measure nutrient use efficiency by crops is presented by Prasad and Hochmuth (2014). The 4Rs is a nutrient management program promoted by the International Plant Nutrition Institute (http://www.ipni.net/4R). We need to develop sets of 4R practicesfor the growers in Florida based on factors such as location, soils, crops produced, water management system, nutrient sources, and agronomic/horticultural management options. In the long run, real-time weather data can be dynamically linked to these 4R sets to guide real-time modifications of the practices during a growing season.

Other Publications in this Series on Soil Testing

Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. *Soil Testing for Plant-Available Nutrients—What Is It and Why Do We Use It*? Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/ss621.

Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. *Developing a Soil Test Extractant: The Correlation and Calibration Processes*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/ss622.

Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. *Fertilizer Recommendation Philosophies*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/ss623.

References

International Plant Nutrition Institute. 2014. http://www.ipni.net/4R.

Prasad, R., and G. Hochmuth. 2014. *How to Calculate a Partial Nitrogen Mass Budget for Potato*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/ss614.

Table 1. Examples of scientific principles behind nutrient management and the associated practices.

	Right Source	**Right Rate**	**Right Placement**	**Right Timing**
Scientific principles	Which nutrients are needed; based on soil testing; potential for nutrient loss	Crops vary in nutrient needs; Crop Nutrient Requirement; prevent excessive amounts	Mobility of nutrients; rooting patterns; bedding of crops; mulching; volatilization	Dynamics of crop growth and nutrient demand; risk of nutrient loss
Application of knowledge	Soil-supplied nutrients; crop residue; fertilizers; manures; blends; single-nutrient source; soluble; CRFs	Costs; nutrient use efficiency; likelihood of nutrient loss; variable-rate application	Band; broadcast; foliar; fertigation; production system, (e.g., no-till); surface vs. buried	Preplant; at planting; first flower; first fruit; logistics of field timing and equipment; mineralization of manure

Controlled-Release and Slow-Release Fertilizers as Nutrient Management Tools[1]

Guodong Liu, Lincoln Zotarelli, Yuncong Li, David Dinkins, Qingren Wang, and Monica Ozores-Hampton[2]

Nutrient management is closely associated with fertilizer type, application rate, application time, and application placement. For example, blueberry plants prefer ammoniacal nitrogen rather than nitrate nitrogen for their growth and development. However, most crops use both ammoniacal and nitrate nitrogen. Proper nutrient management should include the "Four R's" of fertilizer use: apply the right nutrient, at the right rate, at the right time, and in the right place for the selected crop (Mikkelsen 2011). In Florida, there is another R, i.e., the 5th R, the right irrigation, please read https://edis.ifas.ufl.edu/publication/CV296 for more details (Liu et al. 2020). This article focuses on how to select the right fertilizer to enhance profitability and satisfy best management practices (BMPs). There are many fertilizer sources available for commercial crop production. The characteristics of each fertilizer type determine whether its use poses an advantage or a disadvantage to a farmer. This article provides a general overview on quick- and slow-release fertilizers for commercial crop producers, crop consultants, crop advisers, UF/IFAS Extension faculty, researchers, and students who are interested in nutrient management for commercial crop production.

Most used commercial fertilizers are water-soluble quick-release fertilizers (QRFs) that are predictively readily available for plants when properly placed in soil. Quick-release fertilizers are ideal for pre-plant applications, side dressing, hydroponics, or fertigation for many crops, including vegetables. They are highly practical if nutrient leaching or immobilization of nutrients by soil particles is not a serious concern (Wolf 1999), especially if unpredictable, high-leaching/flooding events do not occur. If conditions are favorable, less expensive QRFs have proven to be effective in crop production.

In the best conditions, QRFs become available to plants at a consistent rate (Trenkel 2010). They will release all readily available nutrients in a short period of time after being properly applied to soil with appropriate soil moisture. In other words, their release curve is immediate and does not synchronize with or match the dynamic needs of crop growth, which is why applying timely side dressings is necessary. In fact, crop nutrient requirements change as plants develop. For example, snap bean (Figure 1) has a slow-fast-slow growth stage pattern that has a smaller nutrient requirement in the early stage, a greater nutrient requirement in the middle stage, and a smaller nutrient requirement again in the late stage. Traditionally, multiple fertilizer applications, or side dressings, have been used to accommodate plant nutrient demand, minimize nutrient

1. This document is HS1255, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date October 2014. Revised October 2017 and July 2021. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Guodong Liu, associate professor, Horticultural Sciences Department; Lincoln Zotarelli, associate professor, Horticultural Sciences Department; Yuncong Li, professor, Department of Soil and Water Sciences, UF/IFAS Extension Tropical Research and Education Center; David Dinkins, Extension agent, UF/IFAS Extension Putnam County; Qingren Wang, Extension agent, UF/IFAS Extension Miami Dade County; Monica Ozores-Hampton, associate professor, Horticultural Sciences Department, UF/IFAS Extension Southwest Florida Research and Education Center; UF/IFAS Extension, Gainesville, FL 32611.

losses, and increase fertilizer use efficiency. Using too much fertilizer all at once without timing applications to the plants' growth stage pattern can expose plants to burning and cause nutrient loss through leaching or runoff. It frequently means that nutrients will not be available to plants when they need them. To deal with these challenges, the global fertilizer industry has been working to develop new fertilizers called controlled-release fertilizers (CRFs) and slow-release fertilizers (SRFs). These fertilizers have become more and more popular in recent years (Robbins 2005).

Controlled-Release Fertilizers

The Association of American Plant Food Control Officials defines CRFs as fertilizers that contain a plant nutrient in a form the plant cannot immediately absorb. Uptake is delayed after application, so that CRFs provide the plant with available nutrients for a longer time compared to QRFs, such as urea.

Controlled-release fertilizers are typically coated or encapsulated with inorganic or organic materials that control the rate, pattern, and duration of plant nutrient release. Polymer-coated urea exemplifies CRFs (Du et al. 2006; Loper and Shober 2012). These fertilizers control the release of nutrients with semi-permeable coatings, occlusion, protein materials, or other chemical forms, by slow hydrolysis of water-soluble, low-molecular-weight compounds, or by other unknown means (Trenkel 2010). Most importantly, the release rate of a CRF fertilizer is designed in a pattern synchronized to meet changing crop nutrient requirements.

As required by Florida rule, at soil temperatures below 77°F, a CRF must meet the following three criteria: (1) less than 15 percent of the CRF nutrients should be released in 24 hours, (2) less than 75 percent should be released in 28 days, and (3) at least 75 percent should be released by the stated release time (40–360 days) (Trenkel 1997).

Slow-Release Fertilizers

Nitrogen products decomposed by microbes are commonly referred as SRF fertilizers. Some SRFs such as N-SURE are made in factories. However, some such as manure are naturally originated and cannot be formulated to permit controlled release (Liu et al. 2011). The nutrient release pattern of SRFs is fully dependent on soil and climatic conditions. Slow-release fertilizer releases nutrients gradually with time, and it can be an inorganic or organic form. An SRF contains a plant nutrient in a form that makes it unavailable for plant uptake and use for some time after the fertilizer is applied. Such a fertilizer extends its bioavailability significantly longer than QRFs such as ammonium nitrate, urea, ammonium phosphate, or potassium chloride.

Nitroform (also referred to as trinitromethane with a chemical formula $HC[NO_2]_3$) exemplifies inorganic SRF fertilizers (Loper and Shober 2012). Urea-formaldehyde (UF), urea-isobutyraldehyde/isobutylidene diurea (IBDU), and urea-alcetaldehyde/cyclo diurea (CDU) typify organic SRF fertilizers (Trenkel 2010). Based on the source, there are two types of SRF fertilizers: natural and artificial (Table 1).

Natural SRFs include plant manures, such as green manure or cover crops, all animal manures (chicken, cow, and poultry) and compost (Shukla et al. 2013). Because of their organic nature, these must be broken down by microbial activity before the nutrients can be released to crops. In general, organic fertilizers may take a long time to release nutrients, and these nutrients may not be available when the plant needs them. The duration of nutrient release of this type of organic fertilizers mainly depends on soil microbial activity that is driven by soil moisture and temperature. Organic SRFs contain both macro-nutrients (nitrogen, phosphorus, potassium, etc.) and micro-nutrients (iron, manganese, copper, etc). The nutrient concentrations of organic SRFs are relatively lower than those of synthetic SRF fertilizers. For example, Sup'r Green brand is a chicken manure fertilizer containing only 3-2-2 % N, P_2O_5, and K_2O, respectively.

Synthetic SRFs are sparingly water-soluble. The bioavailability of this type of fertilizers (typically in pellet or spike form) depends on soil moisture and temperature. Nutrients are released throughout a period of time that may range from 20 days to 18 months (Trenkel 2010). Therefore, fewer applications are needed with SRFs, but nutrients are released based upon the temperature and moisture conditions in the soil, which may not match the crop growth demand due to varying weather conditions (Trenkel 2010). Synthetic SRFs often contain a single nutrient at a much higher level than would occur in a natural SRF. For example, N-Sure® is a SRF that contains 28 percent nitrogen (28-0-0) (Clapp 1993; Liu and Williamson 2013)

The Difference between Slow- and Controlled-Release Fertilizers

- The terms "slow-release fertilizer," or SRF, and "controlled-release fertilizer," or CRF, do *not* mean the same thing.

- Controlled-release fertilizer is also known as controlled-availability fertilizer, delayed-release fertilizer, metered-release fertilizer, coated fertilizer (Oertli and Lunt 1962), or slow-acting fertilizer (Gregorich et al. 2001). According to Shaviv (2005), "The term controlled-release fertilizer became acceptable when applied to fertilizers in which the factors dominating the rate, pattern and duration of release are *well known and controllable* during CRF preparation."
- Slow-release fertilizers involve a slower release rate of nutrients than conventional water-soluble fertilizers, but the rate, pattern, and duration of release are *not controlled* (Trenkel 2010) because they depend on microbial organisms whose effectiveness is dependent on soil temperature and moisture conditions.
- Because of their dependence on microbial digestion to enable nutrient availability, SRFs occasionally pose the risk of increased harmful leaching events. This situation occurs when favorable conditions for microbial activity follow after the cropping cycle. Excess available nutrients can be pollutants irrespective of the source.

Advantages of Using CRFs and SRFs

The major advantages for using SRFs or CRFs include:

- Decreased nutrient losses and enhanced nutrient-use efficiency. The application of CRFs and SRFs can potentially decrease fertilizer use by 20 to 30 percent of the recommended rate of a conventional fertilizer while obtaining the same yield (Trenkel 2010).
- Minimization of fertilizer-associated risks such as leaf burning, water contamination, and eutrophication (a process where water bodies receive excess nutrients). The slow rates of nutrient release can keep available nutrient concentrations in soil solution at a lower level, reducing runoff and leaching losses.
- Reduced application and labor costs. For example, in current practices, commercial potato producers use 3 to 4 applications of nitrogen fertilizers for northeast Florida and 2 applications for southwest Florida (personal communication with local potato producers). Eliminating extra applications of fertilizer saves the farmer between $5 and $7/acre broadcasting expense (Liu et al. 2011). Additionally, avoidance of fertilizer application in late growth stage eliminates plant damages to crops.
- Better understanding of nutrient release rate and duration (CRFs only, because they are less sensitive to soil and climate conditions) (Shaviv 2005; Shoji 2005; Trenkel 2010). Knowing when to apply fertilizer and in what quantities saves money, reduces fertilizer-associated risks to crops and the environment, and improves nutrient management programs.
- Lowered soil pH in alkaline soils for better bioavailability of some nutrients. Applying sulfur-coated urea will probably increase soil acidity because both sulfur and urea contribute to increasing the acidity (lowering soil pH) of the soil. Consequently, phosphorus or iron may be more bioavailable and benefit some crops like blueberry, potato, and sweet potato (Liu and Hanlon 2012). In addition, sulfur is an essential nutrient for all crops.
- Reduced production costs if there is an abundant supply of SRF sources like manures nearby.

Disadvantages of Using CRFs and SRFs

- Most coated or encapsulated CRFs and SRFs (Tables 1 & 2) cost considerably more to manufacture than conventional fertilizers. This extra cost increases growers' crop production costs. For example, the price was $650 per ton for environmentally smart nitrogen (ESN) (44% N) versus $481 per ton for urea (46 percent N) (Ruark 2012). Environmentally smart nitrogen was 35.1 percent more costly than urea. The price per unit of nitrogen was 41.3 percent greater for ESN than for conventional urea.
- Applying sulfur-coated urea almost always lowers soil pH as aforementioned. However, this acidification may cause nutrient disorders such as calcium deficiency or magnesium deficiency if there is not a proper nutrient management program.
- Nutrient deficiencies may occur if nutrients are not released as predicted because of low temperatures, flooded or droughty soil, or poor activity of soil microbes.
- Possible uncontrolled nutrient release of SRFs. Use efficiency of SRFs may be enhanced by planting shelter belts or nutrient trap crops where runoff is likely to occur.

How are CRFs or SRFs best used?

Crop nutrient requirements follow a dynamic pattern: they begin low in the early growth stage, increase sharply in the middle stage and decrease in the late stage (Figure 1). Conventional fertilizers (QRFs) are instantly available when they're applied, which makes them more vulnerable to loss from a variety of causes such as ammonia volatilization (ammonia emitting into the atmosphere), de-nitrification (nitrate is reduced to nitrogen), leaching, or runoff after being applied to the soil. Nitrogen and potash fertilizers are particularly easily lost. Assuming the same amount of fertilizer is applied, a one-time or seasonal application of conventional fertilizers has the potential to lose much more nitrogen than would be lost with multiple split-applications of fertilizer (Figure 2). Split applications of convention fertilizer are recommended (Hochmuth and Hanlon 2013).

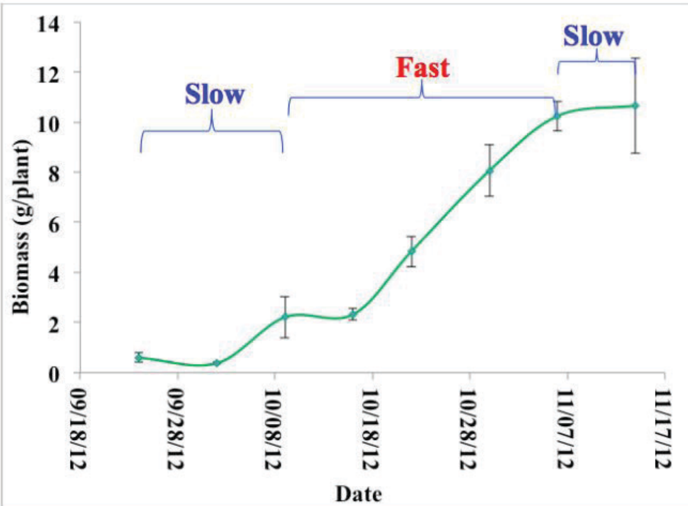


Figure 1. Growth curve of snap bean (variety: Bronco) in fall 2012.
Credits: Guodong Liu, UF/IFAS

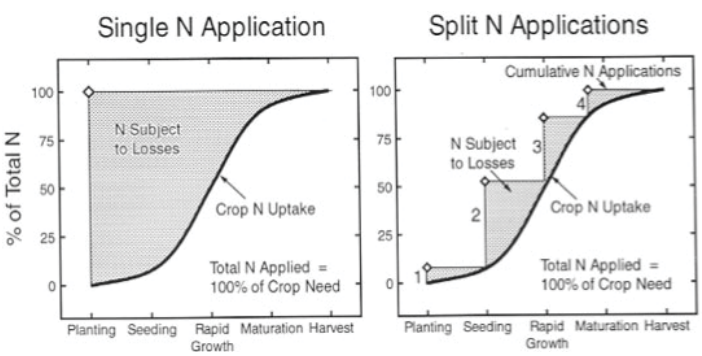


Figure 2. General estimations of potential N losses occurring when N fertilizer is applied in a single application or in split applications.
Credits: Waskom, Cardon, and Crookston

To match crop nutrient requirements, the ideal fertilizer should have this characteristic: the nutrient release matches the nutrient requirements of the crop throughout all of the plant growth stages (Figure 3). Obviously, QRFs do not have this characteristic, and they cannot meet such requirements without repeat applications. Fortunately, using deliberate applications of CRFs and SRFs in specific circumstances where they are appropriate can accommodate timely plant nutrient demand requirements, maximize nutrient use efficiency, and minimize environmental concerns. There is a close relationship between CRFs and BMPs. Section 32 of *Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops (2005 edition)* discusses CRFs and BMPs including planning and application of CRFs.

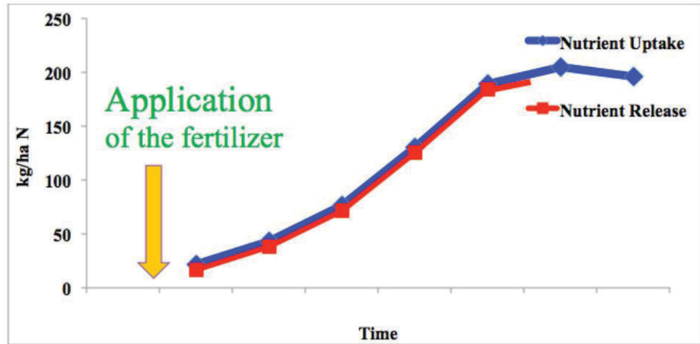


Figure 3. The ideal fertilizer: the nutrient release is synchronized with the crop's nutrient requirements.
Credits: Adapted from Lammel 2005

Take-Home Message

- Quick-release fertilizers are water soluble and readily available for plants to take up when they are properly placed at the right time.
- Controlled-release fertilizers contain a plant nutrient in a form that delays its availability for plant uptake and use after application, or that extends its availability to the plant significantly longer than "rapidly available fertilizers" such as ammonium nitrate or urea, ammonium phosphate, and potassium chloride.
- Controlled-release fertilizers can dynamically release nutrients and meet the crop's changing nutrient demand throughout its growth cycle, maximize nutrient use efficiency, and minimize environmental concerns.
- Slow-release fertilizers generally have a slower release rate of the nutrient than conventional water-soluble fertilizers and CRFs. However, the rate, pattern and duration of release are *not well controlled* because they are dependent on microbial activity that is driven by soil moisture and temperature conditions. Slow-release fertilizers can occasionally be released very quickly when excessive moisture and high temperatures occur in the same period.
- Use of CRFs or SRFs can reduce nutrient losses, increase nutrient-use efficiency, and protect the environment. Thus, the application of CRFs or SRFs is a Best Management Practice (BMP) tool for crop production.

References

Clapp, J.P., Jr. 1993. "Foliar application of liquid urea-triazone-based nitrogen fertilizers and crop safety." 3(4): 442–444.

Du, C., J. Zhou, A. Shaviv. 2006. Release Characteristics of Nutrients from Polymer-coated Compound Controlled Release Fertilizers. *Journal of Polymers and the Environment* 14 (3): 223–230. https://link.springer.com/article/10.1007/s10924-006-0025-4

Gregorich, E. G., L. W. Turchenek, M. R. Carter, and D. A. Angers. 2001. *Soil and Environmental Science Dictionary*. CRC Press. p. 132. ISBN 978-0-8493-3115-2. LCCN 2001 S592.S49 2001. Retrieved 30 December 2013.

Lammel, J. 2005. "Cost of the different options available to the farmers: Current situation and prospects." *IFA International Workshop on Enhanced-Efficiency Fertilizers*. Frankfurt. International Fertilizer Industry Association, Paris, France.

Liu, G., E. H. Simonne, K. T. Morgan, G. J. Hochmuth, S. Agehara, and R. Mylavarapu. 2020. 2020–2021 Vegetable Production Handbook: Chapter 2. Fertilizer Management for Vegetable Production in Florida. CV296. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/publication/CV296

Loper, S. and A. L. Shober. 2012. *Soils & Fertilizers for Master Gardeners: Glossary of Soil and Fertilizer Terms*. SL 277. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/publication/MG457

Oertli, J. J. and J. Lunt. 1962. "Controlled release of fertilizer minerals by encapsulating membranes: I. Factors influencing the rate of release." *Soil Sci. Soc. Proc*. 26: 579–583.

Robbins, J. "Slow-release fertilizers as tools." *IFA International Workshop on Enhanced-Efficiency Fertilizers*. Frankfurt, Germany, 28–39 June 2005.

Ruark, M. 2012. "Advantages and disadvantages of controlled-release fertilizers." https://soilsextension.webhosting.cals.wisc.edu/wp-content/uploads/sites/68/2014/02/Overview_of_fertilizer_technologies_2012_WIFFVC.pdf

Shaviv, A. 2000. "Advances in controlled release of fertilizers." 71: 1–49.

Shukla, S., E. A. Hanlon, F. H. Jaber, P. J. Stoffella, T. A. Obreza, and M. Ozores-Hampton. 2013. *Groundwater Nitrogen: Behavior in Flatwoods and Gravel Soils Using Organic Amendments for Vegetable Production*. CIR 1494. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/publication/AE400

Trenkel, M. E. 2010. "Slow- and Controlled-Release and Stabilized Fertilizers: An Option for Enhancing Nutrient Use Efficiency in Agriculture." *International Fertilizer Industry Association (IFA)* Paris, France.

Waskom, R. M., G. E. Cardon, and M. A. Crookston. 1994. "Best Management Practices for Irrigated Agriculture." *Colorado Water Resources Institute Report* No. 184.

Wolf, B.. 1999. *The Fertile Triangle: The Interrelationship of Air, Water, and Nutrients in Maximizing Soil Productivity*. Binghamton, NY: The Haworth Press, Inc.

Table 1. Relative insoluble synthetic materials used as slow-release fertilizers.

Material	Trade name	N	P_2O_5	K_2O	Mg
Guanylurea	G. sulfate	37			
Magnesium ammonium phosphate	Mag-Amp	8	40	0	14
Oxalic acid diamide	Oxamide	31.8	0	0	0
Potassium calcium phosphate	KCP	0	17–22	21–22	0
Potassium poly-phosphate	KPP	29–32	24–25	0	0
Urea aldehyde	IBDU	30	0	0	0
	CDU	32	0	0	0
	Crotadur	32	0	0	0
	Floranid	28	0	0	0
	Glyyccluril	39	0	0	0
	Ureaform	38	0	0	0
	Agriform	28	18	4.8	0
	Urea-Z	33–38	0	0	0

Dinauer, R. C. 1971. *Fertilizer Technology and Use*. Soil Science Society of America, Inc., Madison, WI.

Hignett, T. P., E. Fredderick, and B. Halder (Eds.). 1979. *Fertilizer Manual*. International Fertilizer Developemt Center. Muscle Shoals, AL.

Wolf, B. 1999. *The Fertile Triangle: The Interrelationship of Air, Water, and Nutrients in Maximizing Soil Productivity*. The Haworth Press, Inc. Binghamton, NY.

Table 2. Relative insoluble synthetic materials used as controlled-release fertilizers.

Material	Trade name	N	P_2O_5	K_2O	Mg
Resin coated	Osmocote	14	14	14	0
		18	9	9	0
		18	6	12	0
		24	4	8	0
	Sierrablen	19	6	10	0
	Polyon	25	4	12	0
	Procote	20	3	10	0
	Nutricote	13	13	13	0
		18	6	18	0
		14	14	14	0
		16	10	10	0
		20	7	10	0
		18	6	8	0
	Woodlace	20	4	11	0
	SCU	37	0	0	0
	ESN	44	0	0	0
	Agrocote	39	0	0	0
		38	0	0	0

Dinauer, R. C. 1971. *Fertilizer Technology and Use*. Soil Science Society of America, Inc., Madison, WI.

Hignett, T. P., E. Fredderick, and B. Halder (Eds.). 1979. *Fertilizer Manual*. International Fertilizer Developemt Center. Muscle Shoals, AL.

Wolf, B. 1999. *The Fertile Triangle: The Interrelationship of Air, Water, and Nutrients in Maximizing Soil Productivity*. The Haworth Press, Inc. Binghamton, NY.

Useful Livestock Management Resources

UF | IFAS Extension
UNIVERSITY of FLORIDA

UF/IFAS PEER REVIEWED SS-AGR-424

Forage-Based Heifer Development Program for North Florida[1]

Jose Dubeux, Nicolas DiLorenzo, Kalyn Waters, and Jane C. Griffin[2]

Introduction

Florida has approximately 915,000 beef cows and 125,000 replacement beef heifers (USDA 2016). Developing these heifers to become productive females in the cow herd is a tremendous investment in a cow-calf operation that takes several years to make a return. Fortunately, there are several options to develop heifers on forage-based programs that can help reduce costs while meeting required industry performance targets. Mild winters in Florida allow the use of cool-season forages that may significantly enhance the performance of grazing heifers. During the warm season, integration of forage legumes into grazing systems provides additional nutrients to meet the replacement heifer's requirements, allowing her to become pregnant and enter the cow herd. This document proposes a model for replacement heifer development based on forage research trials at the UF/IFAS North Florida Research and Education Center (UF/IFAS NFREC) in Marianna, FL.

Planning is essential for establishing a management plan to develop heifers on forage-based diets. A few benchmarks were established to ensure that the heifer would calve at 24 months of age. We assumed weaning weights of 500 lb at 7 months of age, breeding at 750 lb (62.5% of mature weight), and mature weight of 1,200 lb. These numbers could change based on the needs of each farm. Each phase has a different target based on the forages available during the season and the expected weight gain required to reach the desired performance standard. While the development phase is critical in a replacement heifer's life, producers must continue to manage these heifers after calving. Lactating first-calf heifers must overcome postpartum anestrus, rebreed, and continue to grow until they reach mature weight. Figure 1 shows the overall roadmap for a forage-based heifer development program. This document breaks down the roadmap into specific phases and provides details relevant to forage programs in each phase.

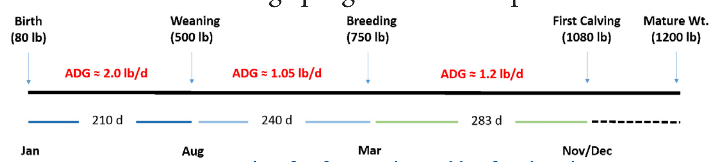


Figure 1. Management plan for forage-based heifer development program in Florida.
Credits: Jose Dubeux, UF/IFAS

From Birth to Weaning

At UF/IFAS NFREC, the calving season takes place during January and February. We use that time frame to select the best forages available to meet the high nutrient requirements of cows at the peak of their lactation. During this time, cool-season forages are available and can provide high nutrition for these cows, resulting in a shortened postpartum interval as well as greater milk production. If we break down Figure 1 and focus only on this phase (January to August), we will also have to use some warm-season

1. This document is SS-AGR-424, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date October 2018. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Jose Dubeux, associate professor, Agronomy Department; Nicolas DiLorenzo, associate professor, Department of Animal Sciences, UF/IFAS North Florida Research and Education Center; Kalyn Waters, CED, Extension agent II, UF/IFAS Extension Holmes County; and Jane C. Griffin, livestock and forages Extension agent I, UF/IFAS Extension Suwannee County; UF/IFAS Extension, Gainesville, FL 32611.

Reviewed: 02/2022

pastures to supply forages for the cow-calf pairs from May to August (Figure 2). It is typically possible to graze cool-season forages until the end of May in north Florida. From May to August, cow-calf pairs could graze bahiagrass or bahiagrass-rhizoma peanut pastures to improve nutrition. Cows have lower nutritional requirements toward the end of lactation. Therefore, well-managed warm-season pastures provide enough nutrients to meet the requirements during this phase.

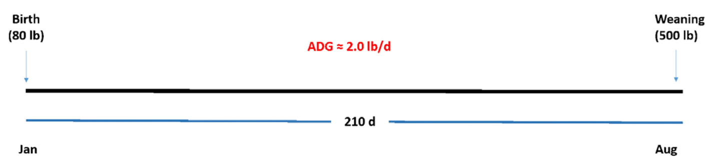


Figure 2. Roadmap from birth to weaning.
Credits: Jose Dubeux, UF/IFAS

From Weaning to Breeding

Weaned calves face weaning stress, a warm summer, and lower-quality forages, which result in lower gains. However, there are ways to overcome these factors and recover weight later in the season. Research results in other regions of the US compared steady gains vs. lower gains in the initial phase and greater gains when approaching the breeding season (Figure 3). The results indicate that both programs can be adopted and yield similar results in reproductive performance of heifers, as long as heifers gain and meet a minimal body weight prior to the breeding season (Freetly, Ferrell, and Jenkins 2001). At UF/IFAS NFREC, heifers are developed using this approach. Therefore, the low-high gain model would be more applicable to match the timing of weaning and available forages during that time.

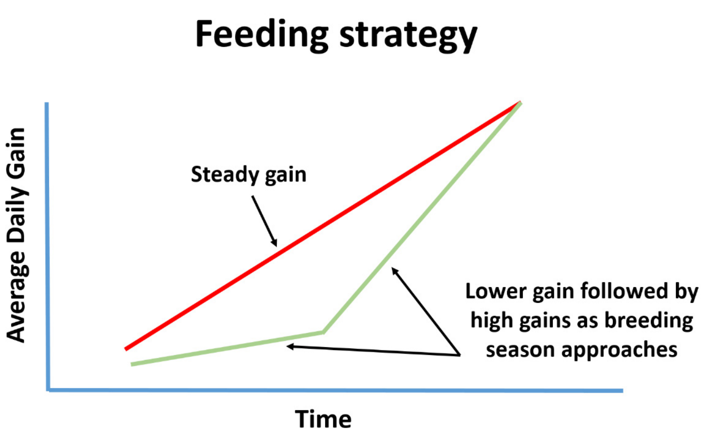


Figure 3. Conceptual model of two different heifer development programs.
Credits: Freetly, Ferrell, and Jenkins (2001)

Bos taurus heifers generally reach puberty at 55–60% of their expected mature body weight, while *Bos indicus*-influenced heifers typically attain puberty around 60–65% of their mature body weight. Heifers should be developed with targeted gains to allow for the attainment of puberty prior to the beginning of the breeding season (Lancaster and Lamb 2014). In order to reach that target body weight, weaned heifers could graze bahiagrass-rhizoma peanut pastures and have an average daily gain of 0.7 lb/day from August to October. Growing steers at UF/IFAS NFREC have experienced similar gain. Yearling animals would gain twice as much on a similar pasture without concentrate. However, one would expect gains to be much lower during the summer months due to weaning stress, greater nutrient requirements, and limited intake. From mid-October to the end of December, the heifers could receive bermudagrass and rhizoma peanut hays with a target average daily gain of 0.5 lb/day. From January until the end of March, when they would breed, they would graze cool-season forages, with an expected gain of 1.8 lb/day (Dubeux et al. 2016). The heifers would gain 252 lb in 240 days, averaging 1.05 lb/day from weaning to breeding (Figure 4).

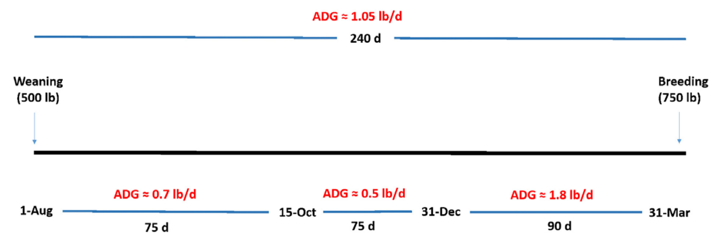


Figure 4. Roadmap from weaning to breeding.
Credits: Jose Dubeux, UF/IFAS

From Breeding to Calving

Heifers should calve at 85–90% of their mature body weight. In order to reach that goal, we must target an average daily gain of 1.2 lb/day from breeding to calving (Figure 5). Since they will be bred in the spring (late March), they can continue on cool-season forages until May with an average daily gain of 1.8 lb/day (Dubeux et al. 2016). During the warm season, these yearling heifers will perform much better than weaned calves on bahiagrass-rhizoma perennial peanut pastures. Our data show gains of 1.23 lb/day on bahiagrass-rhizoma peanut pastures for growing steers (Dubeux et al. 2018), but we projected 1.2 lb/day from May until mid-October. After October, the heifers could be fed bermudagrass and rhizoma peanut hay again until calving with an expected average daily gain of 1.0 lb/day because of greater intake. Although no animal performance data have been generated by the authors when feeding bermudagrass and rhizoma peanut hay only, studies conducted at UF/IFAS NFREC showed that growing heifers fed bermudagrass hay and supplemented with 0.3% of their BW/day with a high-protein meal gained 0.9 lb/day over two consecutive years (Schulmeister et al. 2017). The rhizoma peanut hay should provide the additional protein required for the gain. Further studies are needed to confirm this. The total projected gain during the 283 days using this program would be 349 lb, with an average daily gain of 1.23 lb/day.

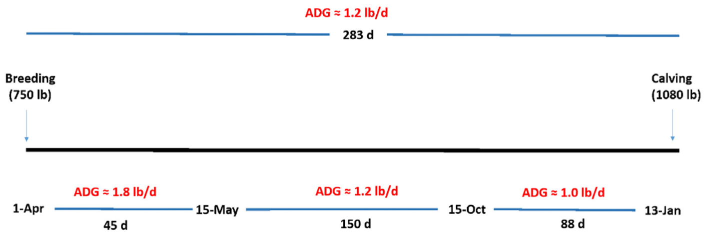


Figure 5. Management plan from breeding to calving.
Credits: Jose Dubeux, UF/IFAS

Conclusion

It is possible to have a forage-based program to develop heifers in Florida. Cool-season forages and the introduction of forage legumes during the warm season and transition periods are important to ensure target gains. In north Florida, integration of crop and livestock systems offers an opportunity to use the land during the fallow period when heifers could have access to cool-season forages. The feasibility of concentrate feeding or forage-based diets is highly dependent on the economics of both systems. Consider the economic needs and constraints of your operation and plan accordingly.

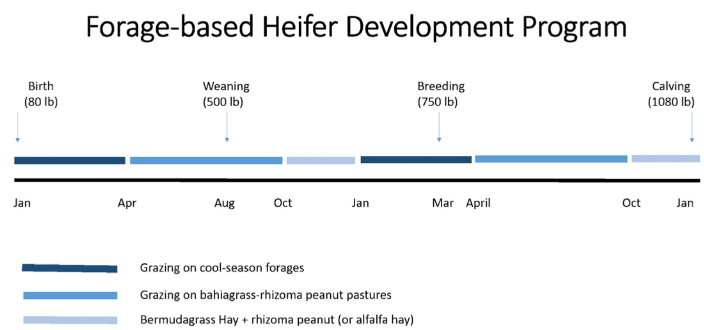


Figure 6. A model for a forage-based heifer development program.
Credits: Jose Dubeux, UF/IFAS

References

Dubeux, Jr., J. C. B., N. DiLorenzo, A. Blount, C. Mackowiak, E. R. S. Santos, H. M. S. Silva, M. Ruiz-Moreno, and T. Schulmeister. 2016. "Animal performance and pasture characteristics on cool-season annual grass mixtures in north Florida." *Crop Sci.* 56: 2841–2852.

Dubeux, Jr., J. C. B., L. E. Sollenberger, J. M. B. Vendramini, M. Wallau, A. Blount, L. Garcia-Jimenez, E. R. S. Santos, and D. Jaramillo. 2018. *Strip-Planting Rhizoma Peanut into Grazing Systems*. SS-AGR-421. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ag421

Freetly, H. C., C. L. Ferrell, and T. G. Jenkins. 2001. "Production performance of beef cows raised on three different nutritionally controlled heifer development programs." *J. Anim. Sci.* 79: 819–826.

Lancaster, P. and C. Lamb. 2014. *Targeting ADG of Developing Replacement Heifers Using Age and Body Weight*. AN305. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/an305

NASEM. 2016. *Nutrient Requirements of Beef Cattle: Eighth Revised Edition*. Washington, D.C.: The National Academies Press. doi: 10.17226/19014.

Schulmeister, T. M., M. Ruiz-Moreno, G. Medeiros, M. Garcia-Ascolani, F. M. Ciriaco, D. D. Henry, G. C. Lamb, J. C. B. Dubeux, Jr., and N. DiLorenzo. 2017. "Evaluation of *Brassica carinata* as a protein supplement for growing beef heifers." In *2017 Florida Beef Research Report*. 107–110. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://animal.ifas.ufl.edu/beef_extension/reports/2017/docs/2017_Florida_Beef_Research_Report.pdf

USDA. 2016. "Florida cattle facts." *U.S. Department of Agriculture—National Agricultural Statistics Service*. Accessed on October 17, 2018. https://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Brochures/FL%20Cattle%20Broc%202016.pdf

Table 1. Nutritional requirements of a replacement heifer.

Body Weight (lb)	Daily Gain	Dry Matter Intake	TDN		Crude Protein	
Development Phase	lb	lb	lb	%	lb	%
500	1.0	12.2	7.2	59	1.19	9.8
	1.5	12.6	8.1	64	1.41	11.2
	2.0	12.7	8.8	69	1.63	12.8
600	1.0	14.0	8.3	59	1.31	9.4
	1.5	14.4	9.2	64	1.53	10.6
	2.0	14.6	10.1	69	1.74	11.9
700	1.0	15.8	9.3	59	1.42	9.0
	1.5	16.2	10.4	64	1.64	10.1
	2.0	16.3	11.2	69	1.85	11.4
Bred Heifers[1]						
750	1.0	16	8.3	53	1.4	8.7
	1.5	16	9.0	55	1.6	9.8
	2.0	17	9.8	58	1.8	10.7
850	1.0	17	9.3	54	1.4	8.2
	1.5	18	10.2	56	1.6	9.1
	2.0	19	11.0	59	1.9	9.9
950	1.0	19	10.3	56	1.5	8.2
	1.5	19	11.1	58	1.7	8.9
	2.0	20	12.0	61	1.9	9.4

[1] Requirements based on 1,200-lb mature body weight, bred heifer in mid-gestation (NASEM 2016). Requirements will increase as gestation progresses and intake capacity will be restricted towards the end of the pregnancy, making it more difficult to achieve target gains based on forage intake only.

Pre-Breeding Considerations for the Development of Replacement Beef Heifers[1]

Pedro L. P. Fontes, Nicky Oosthuizen, Carla D. Sanford, and G. Cliff Lamb[2]

The efficiency of post-weaning development of heifers has a major impact on the overall profitability of cow-calf operations. To ensure satisfactory performance during the first breeding season, replacement heifers must be subjected to an adequate development program. A program should provide proper conditions for heifers to conceive, maintain full-term pregnancies, calve without assistance, wean a healthy calf, and conceive again as first calf-heifers. Knowledge of the basic physiology underlying heifer performance and the available breeding preparation strategies is important. This awareness allows producers to adjust their replacement heifer system and increase the economic returns of their operations.

Age at Puberty, Nutrition, and Target Body Weight Gain

Age at puberty is a major factor that influences reproductive success of beef heifers. Ideally, heifers should reach puberty approximately 60 days before the beginning of their first breeding season, increasing their chances of becoming pregnant and allowing them to conceive earlier in the season.

The timing of first conception is also important to the overall productivity of a heifer. Females that calve at the beginning of their first calving season have been shown to have a greater probability of pregnancy in the subsequent breeding season when bred as first-calf heifers (Patterson et al. 1992). Cows that calve in the beginning of the calving season were also shown to wean heavier calves (Rodgers et al. 2012) and stay productive in the herd for a longer period of time (Cushman et al. 2013). Therefore, increasing the proportion of beef females that calve earlier can increase the economic returns of cow-calf producers (Rodgers et al. 2012; Lamb et al. 2016). Management strategies that lower the age at which heifers reach puberty can have a great impact on the reproductive efficiency of beef heifers and positively affect overall profitability for the producer.

Breed is an important aspect that must be considered when preparing heifers for breeding. Most US heifer herds are composed of *Bos taurus* breeds in which heifers are bred to calve at 2 years of age. However, in the southern states, such as Florida, more than 50% of heifers calve at a later age (Day and Nogueira 2013). This is a result of a greater presence of *Bos indicus* genotype in these particular herds. *Bos indicus*-influenced heifers reach puberty later. Producers generally manage their herds to achieve parturition at 30–36 months of age for this reason. However, *Bos indicus* heifers can be developed to calve at 2 years old if they are properly managed. The use of nutrition strategies and pharmacological treatments that accelerate puberty allows producers with *Bos indicus* cattle to breed heifers to calve at 24 months (Day and Nogueira 2013).

1. This document is AN329, one of a series of the Department of Animal Sciences, UF/IFAS Extension. Original publication date September 2016. Reviewed December 2019. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Pedro L. P. Fontes, master's student; Nicky Oosthuizen, master's student; Carla D. Sanford, PhD student; and G. Cliff Lamb, professor, Department of Animal Sciences; UF/IFAS North Florida Research and Education Center, Marianna, FL 32446.

The period of time that precedes puberty is called the peripubertal period. From an endocrine standpoint, this period is characterized by a wavelike pattern of follicular growth in the ovaries with the occurrence of follicular dominance. However, dominant follicles fail to ovulate during the peripubertal period as a result of negative feedback of estradiol on GnRH secretion. The negative feedback of estradiol decreases as puberty approaches, allowing the secretion of GnRH and LH to increase. Increased LH activity stimulate final follicular growth and maturation of the dominant follicles, therefore increasing estradiol concentration to a threshold that activates the pre-ovulatory LH surge and causes ovulation.

The mechanisms that control the decrease in the negative feedback of estradiol are not completely understood. Nevertheless, it is well-documented that nutrition is a key factor that influences age at puberty and, consequently, reproductive performance of heifers (Patterson et al. 1992; Day and Nogueira 2013). An adequate plane of nutrition is required for pregnancy to occur. When establishing the nutritional scheme for a heifer development program, it is important to consider that *Bos taurus* beef heifers generally reach puberty at 55%–60% of their expected mature body weight. With that in mind, the use of a target average daily gain (ADG) is a common and effective way to prepare heifers for breeding. It is recommended that *Bos indicus*-influenced heifers achieve 60%–65% of their mature body weight before the breeding season starts (Lancaster and Lamb 2014). A nutritional program should be capable of providing sufficient energy and protein to heifers so they can attain this final target weight before the beginning of the breeding season.

Pelvic Area Measurements and Reproductive Tract Score

Dystocia is a constant concern in heifer management. The incidence of dystocia is increased in heifers that are not fully grown at the time of first calving. Heifers with small pelvic areas are more likely to have greater calving difficulty. The measurements of pelvic area can help producers determine which animals are ready to be exposed to breeding and decrease the risk of dystocia by helping them select animals with larger birth canals (Troxel 2011).

Another valuable pre-breeding strategy is the use of reproductive tract scores (RTS). The RTS is utilized to assess reproductive maturity and determine a heifer's ability to conceive. Through rectal palpation or ultrasonography, the reproductive tract structures are evaluated. Each heifer receives a score from 1 to 5 (Table 1) based on their uterine and ovarian characteristics. This information allows producers to select heifers that have greater chances of becoming pregnant as replacement heifers and to potentially cull late-maturing females.

Table 1. Reproductive tract score (RTS) description.

RTS	Uterine Horns	Ovarian Structure
1	<20 mm diameter, no tone	No palpable structure
2	20–25 mm diameter, no tone	8 mm follicles
3	25–30 mm diameter, slight tone	8–10 mm follicles
4	30 mm diameter, good tone	>10 mm follicles, corpus luteum possible
5	>32 mm diameter, good tone, erect	>10 mm follicles, corpus luteum present

Adapted from Anderson et al. (1991).

Herd Health

Adequate herd health is essential for optimal performance. Several diseases (such as Infectious Bovine Rhinotracheitis, Bovine Viral Diarrhea, brucellosis, leptospirosis, trichomoniasis, campylobacteriosis, and neosporosis) can cause embryonic loss and abortion, which result in significant economic losses. Fortunately, the majority of diseases in heifers can be controlled with proper vaccination protocol and adequate nutrition. Standard vaccination protocols are available (Table 2), but working closely with veterinarians once they have become familiar with the operations and the local diseases that can impact the herd is advisable. The veterinarian also has an important role in the establishment of management strategies that assist in the control of infectious diseases. An example of management strategy is the breeding soundness examination of bulls prior to the breeding season, which helps to control certain diseases and prevent poor results related to male infertility (Dahlen and Stokka 2015). The control of parasites is also important. Adequate deworming protocols are required to guarantee desirable animal performance.

Table 2. Standard vaccination protocol.*

Vaccine	Period of Vaccination
Clostridium	3 months and weaning
IBR	Weaning and prior to breeding
BVD-PI3	Weaning and prior to breeding
BRSV	Weaning and prior to breeding
Brucellosis**	4–12 months
Campylobacteriosis (Vibriosis)	Weaning and prior to breeding
Leptospirosis	Weaning and prior to breeding

*Producers should work with their veterinarian to choose a vaccination protocol that fits their operation.
**States with brucellosis-free status do not require vaccination.

Conclusion

The profitability of beef cow-calf operations depends on an adequate heifer replacement system. The reproductive performance of heifers relies on the use of adequate management strategies during the pre-breeding period. Understanding the mechanisms that control the age of puberty can help producers comprehend the available heifer development strategies and customize a development program that fits their own operations.

References

Anderson, K. J., D. G. Lefever, J. S. Brinks, and K. G. Odde. 1991. "The use of reproductive tract scoring in beef heifers." *Agri-Practice* 12: 19.

Cushman, R. A., L. K. Kill, R. N. Funston, E. M. Mousel, and G. A. Perry. 2013. "Heifer calving date positively influences calf weaning weights through six parturitions." *J. Anim. Sci.* 91: 4486–4491.

Dahlen, C., and G. L. Stokka. 2015. "Soundness examinations." Accessed on October 25, 2016. https://www.ag.ndsu.edu/pubs/ansci/livestoc/as1755.pdf

Day, M. L., and G. P. Nogueira. 2013. "Management of age at puberty in beef heifers to optimize efficiency of beef production." *Anim. Front.* 3: 6–11.

Lamb, G. C., V. R. G. Mercadante, D. D. Henry, P. L. P. Fontes, C. R. Dahlen, J. E. Larson, and N. DiLorenzo. 2016. "Invited Review: Advantages of current and future reproductive technologies for beef cattle production." *Prof. Anim. Sci.* 32: 162–171.

Lancaster, P., and C. Lamb. 2014. *Targeting ADG of Developing Replacement Heifers Using Age and Body Weight*. AN305. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://www.edis.ifas.ufl.edu/an305

Patterson, D. J., R. C. Perry, G. H. Kiracofe, R. A. Bellows, R. B. Staigmiller, and L. R. Corah. 1992. "Management considerations in heifer development and puberty." *J. Anim. Sci.* 70: 4018–4035.

Rodgers, J. C., S. L. Bird, J. E. Larson, N. DiLorenzo, C. R. Dahlen, A. Dicostanzo, and G. C. Lamb. 2012. "An economic evaluation of estrous synchronization and timed artificial insemination in suckled beef cows." *J. Anim. Sci.* 90: 4055–4062.

Troxel, T. 2011. "Pelvic area measurements in the management of replacement heifers." Accessed on October 25, 2016. http://agris.fao.org/agris-search/search.do?f=2013/US/US201300350000035.xml;US201300003567.

UF | IFAS Extension
UNIVERSITY of FLORIDA

AN305

https://doi.org/10.32473/edis-an305-2021

Targeting ADG of Developing Replacement Heifers Using Age and Body Weight[1]

John Arthington and Philipe Moriel[2]

Target Audience and Purpose

This EDIS publication was prepared to assist beef cattle producers and livestock agents in determining the target ADG and management system to develop replacement beef heifers in Florida.

Age and Body Weight at Puberty

Heifer development continues to be one of the largest expenses to cow-calf operations, primarily due to cost of feed. Replacement heifers should be bred to calve at 24 months of age in order to maximize lifetime productivity of breeding females. Therefore, heifers should conceive at 15 months of age and achieve puberty at 13–14 months of age because heifers are infertile on the pubertal estrous cycle. For heifers to achieve puberty at 13–14 months of age, adequate nutrition is required to provide moderate rates of gain post-weaning (1.5–2.0 lb/d) so that heifers can achieve a critical body weight prior to reaching puberty. The average daily gain (ADG) needed to reach the target body weight depends upon body weight at weaning and number of days until the start of the breeding season.

Body weight is a primary determinant of puberty attainment in beef heifers. Beef heifers usually achieve puberty at 55%–60% of mature body weight with heifers of more *Bos indicus* breeding being at the upper end of this range. For instance, a recent three-year study conducted at Ona demonstrated that Brangus crossbred heifers achieved puberty at 56%–60% of mature body weight (assuming an average mature herd body weight of 1,100 lb) (Moriel et al. 2017; Moriel et al. 2020). *Bos indicus* heifers will also be older at puberty than *Bos taurus* heifers, making it even more difficult for *Bos indicus* and *Bos indicus* crossbred heifers to become pregnant and calve at 24 months of age. When developing replacement heifers, a target body weight method has been used, where heifers are provided a level of nutrition that will allow them to reach 60%–65% of mature body weight prior to the breeding season.

Recently, a dataset was compiled of published research data to evaluate the relationships among age and body weight at puberty and rate of gain from weaning to breeding in replacement beef heifers. This dataset includes *Bos taurus*, *Bos indicus*, and *Bos taurus* × *Bos indicus* heifers. Unfortunately, there are not enough data points of each breed type to evaluate the individual breed types. The results described are based on analysis including all breed types that may reflect the expected outcome of *Bos taurus* × *Bos indicus* breed type.

As post-weaning rate of gain increases, age at puberty decreases (Figure 1), which is expected because heifers will achieve the target body weight at a younger age. In Figure 2, as post-weaning rate of gain increases, body weight at puberty increases, which may be unexpected based on the target body weight concept. Based on the target body weight concept, there should be no relationship between

1. This document is AN305, one of a series of the Department of Animal Sciences, UF/IFAS Extension. Original publication date September 2014. Revised October 2021. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. John Arthington, professor and center director, UF/IFAS Range Cattle Research and Education Center; and Philipe Moriel, associate professor, Department of Animal Sciences; UF/IFAS Range Cattle Research and Education Center, Ona, FL 33865.

body weight at puberty and post-weaning rate of gain. Once heifers reach 55%–60% of mature body weight, they should begin cycling no matter the rate of gain to get there. This indicates that other factors may be affecting attainment of puberty.

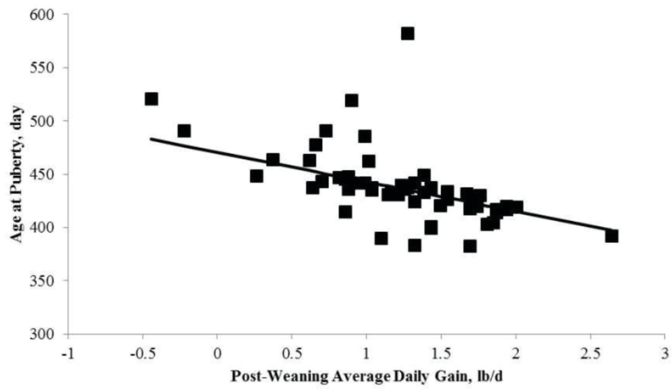


Figure 1. Relationship between age at puberty and post-weaning ADG in replacement beef heifers of *Bos taurus*, *Bos indicus*, and *Bos taurus* × *Bos indicus* breeding. Age = 470.55 ± 22.31 – 27.72 ± 5.62 × ADG; R^2 = 0.34; $P < 0.01$.
Credits: John Arthington and Philipe Moriel

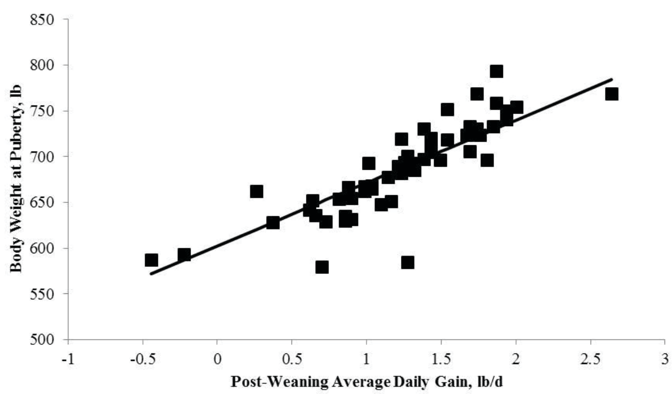


Figure 2. Relationship between body weight at puberty and post-weaning ADG in replacement beef heifers of *Bos taurus*, *Bos indicus*, and *Bos taurus* × *Bos indicus* breeding. BW = 602.56 ± 21.11 + 68.72 ± 9.99 × ADG; R^2 = 0.72; $P < 0.01$.
Credits: John Arthington and Philipe Moriel

One factor that may impact attainment of puberty in heifers is age. Previous research using five breeds and their crosses indicates that a minimum age and minimum body weight are required for heifers to achieve puberty (Nelsen et al. 1982). Thus, in the dataset compiled, it is possible that heifers fed for increased rates of gain surpassed the minimum body weight before the time they reached the minimum age necessary to attain puberty. This would result in these heifers having increased body weight at puberty. To evaluate whether a minimum age is required to achieve puberty, the relationship between age at puberty and body weight at puberty was determined (Figure 3). A definite break point is evident in this relationship such that even though body weight at puberty continues to increase, a minimum age at puberty is reached. This indicates that heifer development programs should utilize both a target body weight and minimum age. This would keep from overfeeding heifers to achieve target body weight before they have reached the minimum age that will allow them to achieve puberty, which may reduce feed costs of developing replacement heifers.

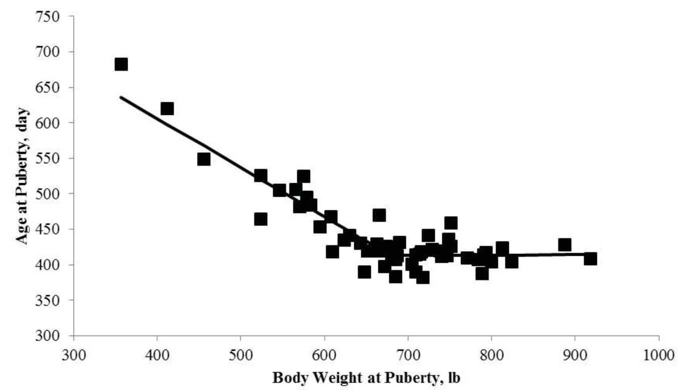


Figure 3. Relationship of age at puberty with body weight at puberty in replacement beef heifers of *Bos taurus*, *Bos indicus*, and *Bos taurus* × *Bos indicus* breeding. Age = 883.24 ± 92.09 – 0.69 ± 0.14 × BW + 0.70 ± 0.19 × BW, where BW ≥ 679 lb; R^2 = 0.86; $P < 0.01$.
Credits: John Arthington and Philipe Moriel

It was determined from this analysis that the critical minimum age to achieve puberty was 412 days of age (13.7 months of age), which coincided with a body weight at puberty of 679 lb. This would represent 56.6%–61.7% of mature body weight, assuming mature body weight is between 1,100 and 1,200 lb, which is typical of cows found in Florida. Our three-year study demonstrated that Brangus crossbred heifers achieved puberty at 401–428 days of age and 610–654 lb of body weight (Moriel et al. 2017). Therefore, feeding heifers to reach 60% of mature body weight at 412 days of age would allow minimum age at puberty without overfeeding.

As a reminder, the analysis described here included *Bos taurus*, *Bos indicus*, and *Bos taurus* × *Bos indicus* heifers. The minimum age at puberty is most likely different for each breed type; caution should be taken when applying the specific minimum age at puberty described here to all breed types. The results of this analysis best reflect the minimum age for *Bos taurus* × *Bos indicus* heifers. Straight *Bos taurus* heifers are typically younger at puberty, whereas straight *Bos indicus* heifers are typically older at puberty.

Pattern of Body Weight Gain

The pattern of body weight gain prior to breeding can impact attainment of puberty by beef heifers. Heifer development programs can be designed for heifers to (1) have a constant rate of gain up to the start of breeding, (2) maintain weight early post-weaning and then gain weight rapidly just prior to breeding, or (3) gain weight rapidly early post-weaning and then maintain weight until the start of the breeding season. These three methods are illustrated in Figure 4.

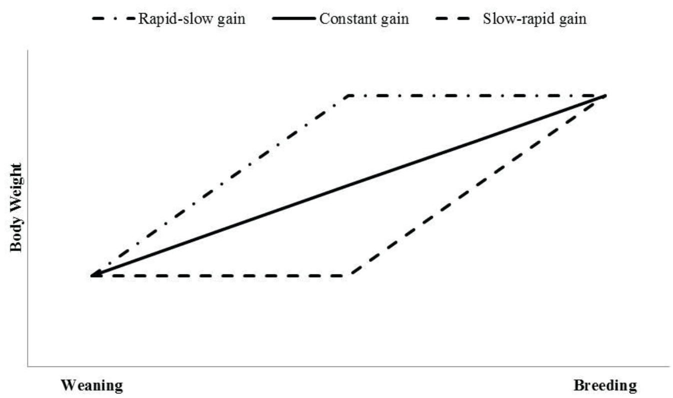


Figure 4. Illustration of different patterns of gain for replacement heifers from weaning to the start of the breeding season.
Credits: John Arthington and Philipe Moriel

The first method is to use a constant rate of gain from weaning to start of breeding. This method requires only moderate energy intake and supplemental feed. Using either of the other two methods (slow-rapid or rapid-slow) will require greater energy intake during the rapid gain period, but equal or less total supplemental feed over the entire feeding period, to attain similar body weight prior to breeding. This may not necessarily decrease feed costs, because feed costs associated with using slow-rapid gain versus constant gain will depend on the relative price of feed ingredients. The advantage of the slow-rapid gain method is that a lighter animal is maintained longer, which will reduce feed required for maintenance and potentially capitalize on compensatory gain of the heifer. However, if compensatory gain is not realized at the magnitude required to achieve a minimum body weight (due to severe drought and limited forage mass, for instance), heifers will not attain puberty before the start of the breeding season. Producers adopting the slow-rapid gain need to make sure that proper nutrition (backup hay and concentrate supplementation) will be available. Using the rapid-slow gain method may seem counterintuitive, because a heavier animal must be maintained late in the feeding period, which would increase feed required for maintenance. However, if less expensive, high-quality feedstuffs such as higher-quality forage are available early post-weaning, then this method may reduce heifer development costs.

Previous research evaluating patterns of body weight gain from weaning to breeding indicates that these methods can be successfully used to develop replacement heifers (Clanton et al. 1983; Hall et al. 1997; Lynch et al. 1997). However, an important aspect is the length of time heifers were fed a high-energy diet. In studies where heifers were fed for rapid gain for only 60 days, age at puberty and proportion of heifers cycling prior to breeding were reduced in the slow-rapid gain heifers even though body weight prior to breeding was similar to constant gain heifers. In contrast, studies where heifers were fed for rapid gain for 80–90 days either early post-weaning or immediately prior to the breeding season have reported similar age at puberty and pregnancy rates to constant gain heifers. Therefore, if slow-rapid or rapid-slow gain methods are used to develop replacement heifers, heifers should be fed a high-energy diet for a minimum of 80 days prior to reaching the target body weight, whether this is early post-weaning or immediately prior to the start of the breeding season.

Early Weaning

A couple of studies have demonstrated that early weaning and plane of nutrition for early-weaned heifers can significantly reduce age and body weight at puberty. In Angus and Simmental heifers, early weaning (112 days of age) and a high-energy diet decreased age at puberty by 100 days and body weight at puberty by 165 pounds compared with early weaning and a moderate-energy diet (Gasser et al. 2006). In a study at the UF/IFAS Range Cattle Research and Education Center, early weaning Brangus crossbred heifers (72 days of age) and feeding a high-energy diet until the time of normal weaning (249 days of age) decreased age at puberty by 131 days and body weight at puberty by 124 pounds compared with normal weaning (Moriel et al. 2014). Early weaning and feeding a high-energy diet also increased the proportion of heifers that were pubertal prior to the breeding season (100% vs. 30% for the early- and normal-weaned heifers, respectively). Additionally, early weaning and feeding the high-energy diet for only 94 days followed by grazing bahiagrass pastures gave similar results as feeding the high-energy diet for the entire 177 days.

Previous studies have reported that age at puberty or age at conception are negatively related with average daily gain pre-weaning, but not with average daily gain post-weaning. This indicates that heifers with faster growth rates pre-weaning attained puberty at a younger age. Additionally, a negative relationship between genetic potential for milk production and age at puberty has been reported, indicating that cows with greater milk yield produce heifers that achieve puberty at a younger age. Therefore, plane of nutrition early in life can significantly impact the ability of heifers to attain puberty prior to the breeding season. This response is attributed to the "metabolic imprinting" effect, a process in which nutrition at early stages of a calf's life is crucial for its development and future performance. For more information, see: EDIS publication AN335, *Nutrition at Early Stages of Life Determines the Future Growth and Reproductive Performance of Beef Calves* (Moriel 2021); and *Nutrient Profiling—Metabolic Imprinting of Beef Calves* (Moriel 2017).

Management practices to increase the plane of nutrition prior to normal weaning (e.g., early weaning and potentially creep feeding) could reduce age and body weight at puberty in beef heifers. However, the cost of extra feed (quality and quantity) and potential mortality losses associated with early weaning and creep feeding need to be considered when calculating the economic benefit of achieving puberty earlier or at a reduced body weight.

Conclusion

Developing beef heifers is a costly aspect of the cow-calf enterprise. Feeding heifers to reach the target body weight (60% of mature weight) before reaching the minimum age that will allow them to attain puberty may increase feed costs. Using slow-rapid or rapid-slow gain methods could reduce feed costs, but a minimum of 80 days on a high-energy diet is recommended for heifers to attain puberty prior to the breeding season. Early-weaning heifers can dramatically decrease age and body weight at puberty and increase proportion of heifers cycling prior to the breeding season, but additional feed costs may be incurred using this development method.

References

Clanton, D. C., L. E. Jones, and M. E. England. 1983. "Effect of Rate and Time of Gain after Weaning on the Development of Replacement Beef Heifers." *J. Anim. Sci.* 56:280–285. https://doi.org/10.2527/jas1983.562280x

Gasser, C. L., D. E. Grum, M. L. Mussard, F. L. Fluharty, J. E. Kinder, and M. L. Day. 2006. "Induction of Precocious Puberty in Heifers I: Enhanced Secretion of Luteinizing Hormone." *J. Anim. Sci.* 84:2035–2041. https://doi.org/10.2527/jas.2005-636

Hall, J. B., R. B. Staigmiller, R. E. Short, R. A. Bellows, M. D. MacNeil, and S. E. Bellows. 1997. "Effect of Age and Pattern of Gain on Induction of Puberty with Progestin in Beef Heifers." *J. Anim. Sci.* 75:1606–1611. https://doi.org/10.2527/1997.7561606x

Lynch, J. M., G. C. Lamb, B. L. Miller, R. T. Brandt, Jr., R. C. Cochran, and J. E. Minton. 1997. "Influence of Timing of Gain on Growth and Reproductive Performance of Beef Replacement Heifers." *J. Anim. Sci.* 75:1715–1722. https://doi.org/10.2527/1997.7571715x

Moriel, P., S. E. Johnson, J. M. B. Vendramini, V. R. G. Mercadante, M. J. Hersom, and J. D. Arthington. 2014. "Effects of Calf Weaning Age and Subsequent Management System on Growth and Reproductive Performance of Beef Heifers." *J. Anim. Sci.* 92:3096–3107. https://doi.org/10.2527/jas.2013-7389

Moriel, P. 2017. *Nutrient Profiling—Metabolic Imprinting of Beef Calves*. 66th Annual Florida Beef Cattle Short Course, Gainesville, FL. http://animal.ifas.ufl.edu/beef_extension/bcsc/2017/proceedings/moriel.pdf

Moriel, P., P. Lancaster, G. C. Lamb, J. M. B. Vendramini, and J. D. Arthington. 2017. "Effects of Post-Weaning Growth Rate and Puberty Induction Protocol on Reproductive Performance of *Bos indicus*-Influenced Beef Heifers." *J. Anim. Sci.* 95:3523–3531. https://doi.org/10.2527/jas.2017.1666

Moriel, P., E. Palmer, M. Vedovatto, M. B. Piccolo, J. Ranches, H. M. Silva, V. R. G. Mercadante, G. C. Lamb, and J. M. B. Vendramini. 2020. "Supplementation Frequency and Amount Modulate Post-Weaning Growth and Reproductive Performance of *Bos indicus*-Influenced Beef Heifers." *J. Anim. Sci.* 98(8): 1–11. https://doi.org/10.1093/jas/skaa236

Moriel, P. 2021. *Nutrition at Early Stages of Life Determines the Future Growth and Reproductive Performance of Beef Calves.* AN335. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/an335

Nelsen, T. C., C. R. Long, and T. C. Cartwright. 1982. "Postinflection Growth in Straightbred and Crossbred Cattle. II. Relationships among Weight, Height, and Pubertal Characteristics." *J. Anim. Sci.* 55:293–304. https://doi.org/10.2527/jas1982.552293x

Time to Start Planning for Heifer Development

Fig. 1. Heifer development at the NFREC Feed Efficiency Facility Credit: Nicolas DiLorenzo

Nicolas DiLorenzo*, State Beef Specialist, University of Florida NFREC*

Even in this current, somewhat depressed, cattle market, replacement females for the Florida commercial cow herd are an annual expense of approximately $400 million. Development and selection of the best females to join a productive herd is one of the most challenging aspects of a beef operation, and two of the keys for success, not surprisingly, are: 1) start early and 2) have a plan. Weaning time is not far off.

In order to achieve the target body weight for a cycling heifer at breeding, some hurdles need to be cleared. The first challenge is to achieve an ideal average daily weight gain (ADG) to avoid over-conditioning and fat deposition, while still gaining weight at a rate that would ensure achieving the target weight in a timely manner. The main reason why this can be so difficult, is because when doing calculations about typical weaning weights and dates, and desired weight at the beginning of the breeding season, this yields a very narrow target ADG in the range of 1.5 to 2.25 lbs/d. This is often referred to as the ideal rate of gain for heifers to avoid over or under conditioning.

To complicate things even further, these newly weaned heifers will need to have a high enough protein concentration in their diet to support muscle growth, which is critical in a growing animal. When all things are considered, the ideal heifer development diet should have approximately 13-14% crude protein, and an energy content that allows the target ADG already discussed. Thus, when considering the byproducts and commodities available in this area, there is not a single one that would be able to meet some of those nutritional requirements by itself without running into metabolic problems. Another challenge then, is to have access to a mixer wagon and feed storage space in order to blend an ideal diet.

Assuming that the mixer and commodity storage are not an issue, the next problem typically is time and labor to limit feed the heifers to avoid excessive weight gains. It is possible to provide free choice feeds to target the optimal gains, but this needs to be done carefully so that nutrients are well balanced in the total mixed ration (TMR). At the University of Florida-NFREC, heifers have been developed over the last 5 years feeding a free choice diet comprised of 51% fiber pellets (**AFG Feed, LLC**), 22% soyhull pellets, 22% corn gluten feed pellets, and 5% of a supplement to balance minerals and provide the ionophore monensin. With this diet (13% CP, 55% TDN), heifers have ranged from 2 to 2.45 lb/d in the last few years. While these rates of gain are on the higher end of the ideal, they provide a great opportunity for the use of byproducts. There is also an option to add more fibrous ingredients (ground hay, cottonseed hulls, etc.) to decrease the rate of gain and reduce the cost of the diet.

Another approach that has been successful for many years is the use of winter annuals such as oats, triticale, rye or combinations of those. The rates of gain on a typical year (not the case of the last spring) for cattle on winter annuals are usually in the correct range (1.7-2.2 lb/d), and protein usually is not limiting. The use of winter annuals for heifer development provides a great opportunity for producers in the Panhandle, however given the variability in weather from year to year, and assuming irrigation is not an option, it may be important to have a backup plan to avoid arriving at the beginning of the breeding season with heifers in sub-optimal condition.

Take Home Message

Developing heifers with the use of byproduct feeds and commodities is an attractive option in the Panhandle of Florida. The rate of weight gain for developing heifers needs to be considered carefully, so it is imperative to plan ahead to have the feed resources available to achieve 1.5 to 2.25 lbs/hd/d. The use of winter annuals also provides an opportunity for heifer development in North Florida, considering the nutritive profile of most of those forages. However due to the reliance on adequate rainfall, it is a good idea to have a back up plan, if the forage production is not optimal.

Alachua County
Cindy Sanders
County Extension Director - Livestock
CBSanders@ufl.edu
(352) 955-2402

Kevin Korus
Agriculture / Natural Resources
kkorus@ufl.edu
(352) 955-2402

Baker County
Alicia Halbritter
Agriculture / Natural Resources
aliciah1221@ufl.edu
(904) 259-3520

Bradford County
Lizzie Whitehead
Livestock / Forages
liz.whitehead@ufl.edu
(904) 966-6224

Citrus County
Ky Sales
Agriculture / Natural Resources
c.rossisales@ufl.edu
(352) 527-5721

Clay County
Cassidy Dossin
Agriculture / Natural Resources
cdossin@ufl.edu
(904) 284-6355

Columbia County
Paulette Tomlinson
Livestock / Natural Resources
apt@ufl.edu
(386) 752-5384

Duval County
Stephen Jennewein
Small Farms and Alternative Enterprises
sjennewein@ufl.edu
(904) 255-7450

Gilchrist County
Tyler Pittman
Agriculture / Natural Resources
Pittmanh1@ufl.edu
(352) 463-3174

Hamilton County
Keith Wynn
Agriculture / Livestock
kwynn@ufl.edu
(386) 792-1276

Levy County
Ed Jennings
County Extension Director- Livestock
edjennin@ufl.edu
(352) 486-5131

Madison County
Dan Fenneman
Agriculture / Livestock
dfenneman@ufl.edu
(850) 973-4138

Nassau County
David Hebert
Agriculture / Natural Resources
David.hebert@ufl.edu
(904) 530-6356

Suwannee County
Erin Jones
Livestock / Forages
Erinj1295@ufl.edu
(386) 362-2771

Union County
Luke Harlow
Agriculture / Natural Resources
harlow1231@ufl.edu
(386) 496-2321

Izabella Michelon Toledo
Regional Specialized Agent II
lizatol@ufl.edu
(386) 294-1279

Marcelo Wallau
Forages Extension Specialist
mwallau@ufl.edu
(352) 273-2216