SELECTING SOILS FOR ALFALFA ON THE COASTAL PLAIN OF THE SOUTHERN USA

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The Coastal Plain extends across the southern US from eastern Texas into Arkansas, parts of Missouri and Kentucky, and eastward to the Atlantic states. Soils on the Coastal Plain predominantly are low in organic matter (<1.0%), sandy, acid, infertile, and leached by high rainfall. Average annual rainfall varies around ± 45 inches (±1150 mm) across this region. Strongly acid subsoils that can cause aluminum (Al) and manganese (Mn) toxicities are common, and sand depths can vary from 6 inches to >40 feet (15 cm to 12 m) in these soils.

Until recently, alfalfa has not been a sustainable forage crop on the Coastal Plain because of soil acidity, excessively wet soils, poor fertility, and the relative ease of growing bermudagrasses and bahiagrasses that have few production problems. Also, the soil problems that inhibit growth of alfalfa had not been adequately researched. Interest in growing alfalfa on the Coastal Plain stimulated research in the late 1980s to determine the soils problems that inhibit growth of this high nutritive value forage legume. The success of these studies was evaluated in on-ranch USDA SARE funded studies of alfalfa production in 2000- 2004 and the results are shown below:

Why Grow Alfalfa on Coastal Plain Soils?

Four-year alfalfa production economics on stakeholder ranches in a S. SARE funded study conducted from Texas A&M- Overton.

	Ranch 1	Ranch 2	Ranch 3	Ranch 4
	----------$/acre----------			
Establishment cost	**232**	**253**	**326**	**353**
Hay value	**2348**	**2612**	**2231**	**1913**
Production expenses†	**1359**	**1406**	**1336**	**1395**
Net return, total	**989**	**1206**	**895**	**518‡**
Avg. net return/year	**247**	**302**	**224**	**130**

†Include production costs, custom hay harvesting and hauling, interest, and overhead (machinery, land, equipment, and establishment costs prorated over 4 yr) Alfalfa valued at $135/ton of 12% moisture hay.

‡Includes a 1-yr negative return from only two harvests because of extended grazing periods. Cattle weight gain not measured.

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In four years of production, alfalfa managed for hay returned net income ranging from $130/acre on a poor harvest-management site to $302/acre when alfalfa hay was valued at $135/short ton. Establishment costs that ranged from $232 to $353/acre were prorated over four years. These costs varied depending on the amount of limestone needed to raise pH in the surface soil to near 7.0, fertilizer costs, and site preparation needed to establish a proper seedbed for alfalfa. The net returns show well-managed alfalfa is one of the most valuable hay crops that can be grown on the Coastal Plain.

Studies conducted by Texas AgriLife Research scientists with the Texas A&M System at Overton determined that rainfall usually is adequate for four to five hay cuttings, disease problems are minimal and no cotton root rot occurs on limed acid soils, no blister beetles were observed in alfalfa in at least 25 different experiments, and production-related problems that previously hindered alfalfa can be overcome. A plus for alfalfa is that it needs no nitrogen fertilizer because it uses nitrogen taken from the air by Rhizobia that live on roots of alfalfa plants.

A quarter-century of the history of alfalfa production in northeast Texas (from 1983-2008) is shown below along with a picture of field day visitors viewing the first sustainable alfalfa research planting on Darco soil near Overton in the early 1990s. This alfalfa stand lasted eight years. During the 1990's, additional experiments were established to evaluate response of alfalfa to soil pH and boron, soil series and phosphorus, and various other nutrients. Knowledge gained from these studies was applied in the SARE funded studies on producers' fields.

Most Recent 25 Year History of Alfalfa on Coastal Plain Soils in Northeast Texas

- Alfalfa won't grow here mindset- Alfalfa dies in two seasons
- Why is alfalfa not sustainable?
- Advent of grazing tolerant alfalfa
- Alfalfa established on Darco soil
- Limestone x boron rate studies
- Soil series x P rate studies
- Other- K, Mg, S, Zn, Cu, Mo, limestone incorporation
- SARE- funded, on-farm alfalfa production evaluations

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Soil characteristics favorable for alfalfa growth include a native soil pH above 7.0, or acid soils with the four- to six-inch surface depth limed to pH 7.0. Other soil properties favorable for alfalfa include level to gently sloping (0-3%), a well aerated and drained site, and a fertile soil or one that will respond to application of deficient plant nutrients. A common saying is that “alfalfa can’t stand wet feet.” We added another one-liner for alfalfa on Coastal Plain soils that states “if the subsoil is gray stay away.” Limestone application to raise the pH of acid, low-buffer capacity sandy soils to 7.0 for alfalfa ties up plant-available boron. More than two tons of alfalfa dry matter per acre was produced each year by adding four pounds of actual boron/acre on Darco soil limed to pH 7.0.

Soil Characteristics Favorable for Alfalfa Growth

- Well-drained soil- “alfalfa can’t stand wet feet”
  - “if subsoil is gray, stay away”
- Well-aerated soil
- Adequate surface soil pH- Lime acid soils to pH 6.8 – 7.0
- Liming low buffer capacity soil ties up plant available boron

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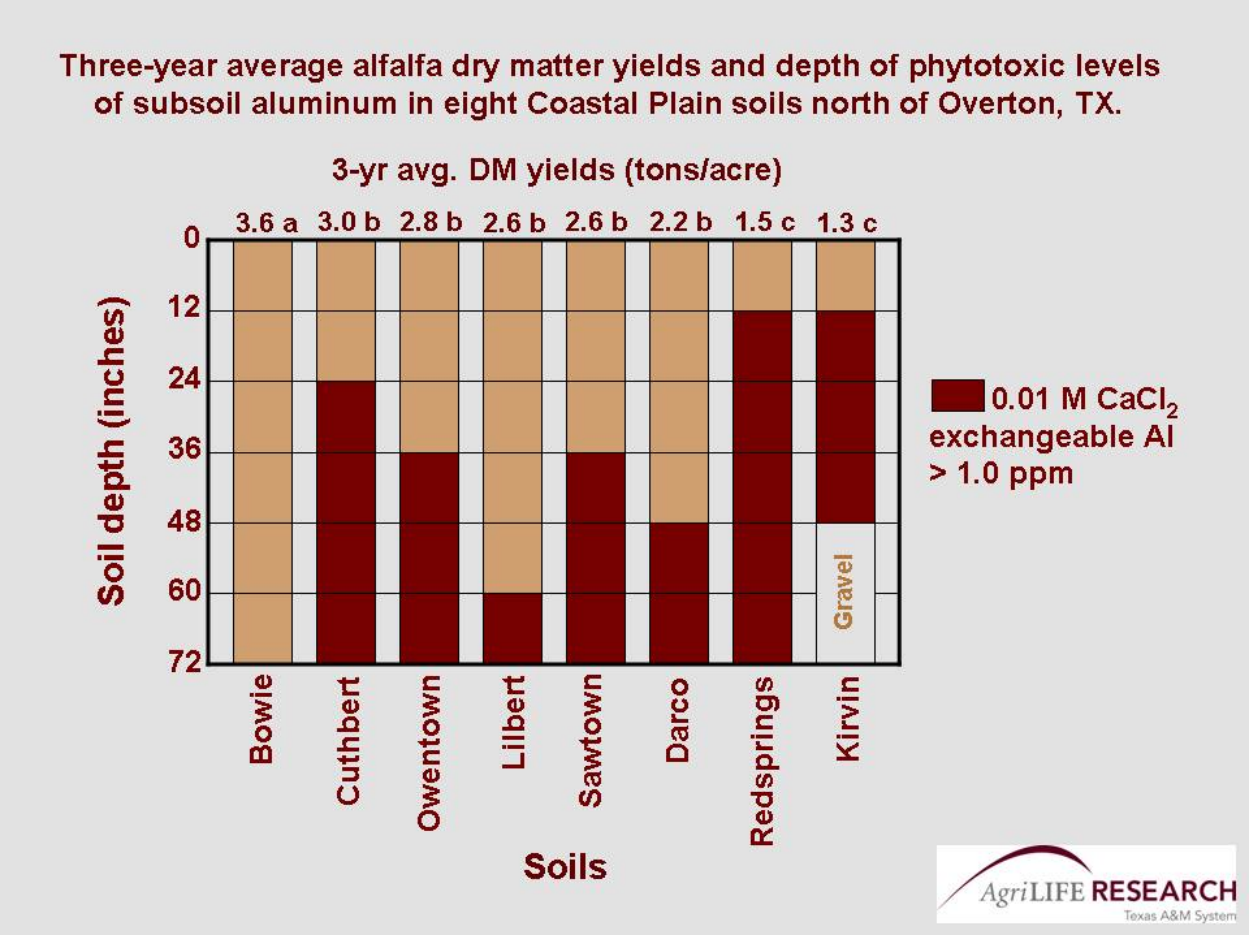
Studies on soil series and phosphorus rates over three seasons showed the decreased production of alfalfa on soils that contain phytotoxic levels of 0.01 molar calcium chloride extractable subsoil aluminum in the profile of eight soils.

The highest three-year average yield, that included one severe drought year, occurred on the Bowie soil that contained no phytotoxic aluminum concentration in the 72-inch depth. Significantly lower yields occurred on the Cuthbert, Owentown, Lilbert, Sawtown, and Darco soils that contained levels of aluminum at the 24-inch depth or lower, that were harmful to alfalfa root growth. The Redsprings and Kirvin soils contained aluminum levels greater than 1.0 ppm near the limed surface and each produced even significantly less alfalfa than the other soils.

The low yields on the Redsprings and Kirvin soils and the intermediate yields on soils that contained exchangeable aluminum in the profile below two-feet deep indicate the inability of alfalfa roots to penetrate these increased concentrations of aluminum. Under these shallow rooting conditions, alfalfa yield declined from lack of water as the low-aluminum, upper soil depths dried during low rainfall periods. These data show the necessity of sampling the soil profile and analyzing these samples for pH and aluminum when selecting soils for alfalfa on the Coastal Plain.



The soil chemistry phase diagram for aluminum indicates that solubility of this element rapidly increases below pH 5.5. These data show that a pH of 5.5 or higher on profile samples of potential sites will be sufficient to indicate the suitability of a Coastal Plain soil for alfalfa.

However, if pH in profile samples is slightly below 5.5, analysis for aluminum may be done to determine acceptance of rejection of the site. Sampling potential soils by one-foot depths to 48-inches deep at five locations in a field and analyzing these depth-composited samples for pH to find suitable sites for alfalfa has worked well. This process was used in the site location process for the on-ranch alfalfa demonstration work reported earlier.

Soil Characteristics Favorable for Alfalfa Growth

- Well-drained soil- "alfalfa can't stand wet feet"
  - "if subsoil is gray, stay away"
- Well-aerated soil
- Adequate surface soil pH- Lime acid soils to pH 6.8 – 7.0
- Liming low buffer capacity soil ties up soil boron
- Alfalfa is intolerant to subsoil acidity, i.e. aluminum

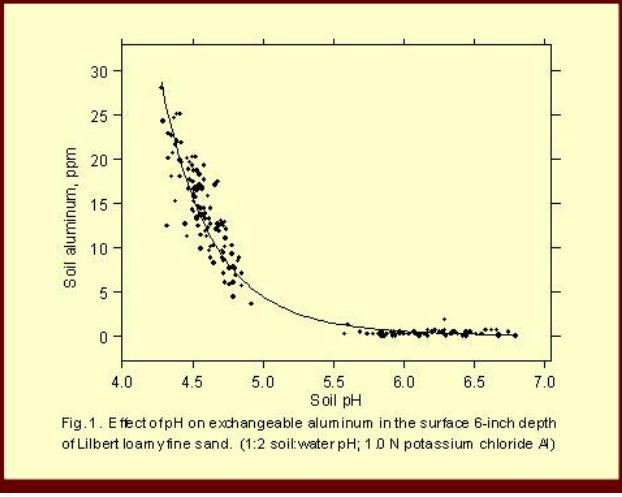


Fig. 1. Effect of pH on exchangeable aluminum in the surface 6-inch depth of Lilbert loamy fine sand. (1:2 soil:water pH; 1.0 N potassium chloride Al)

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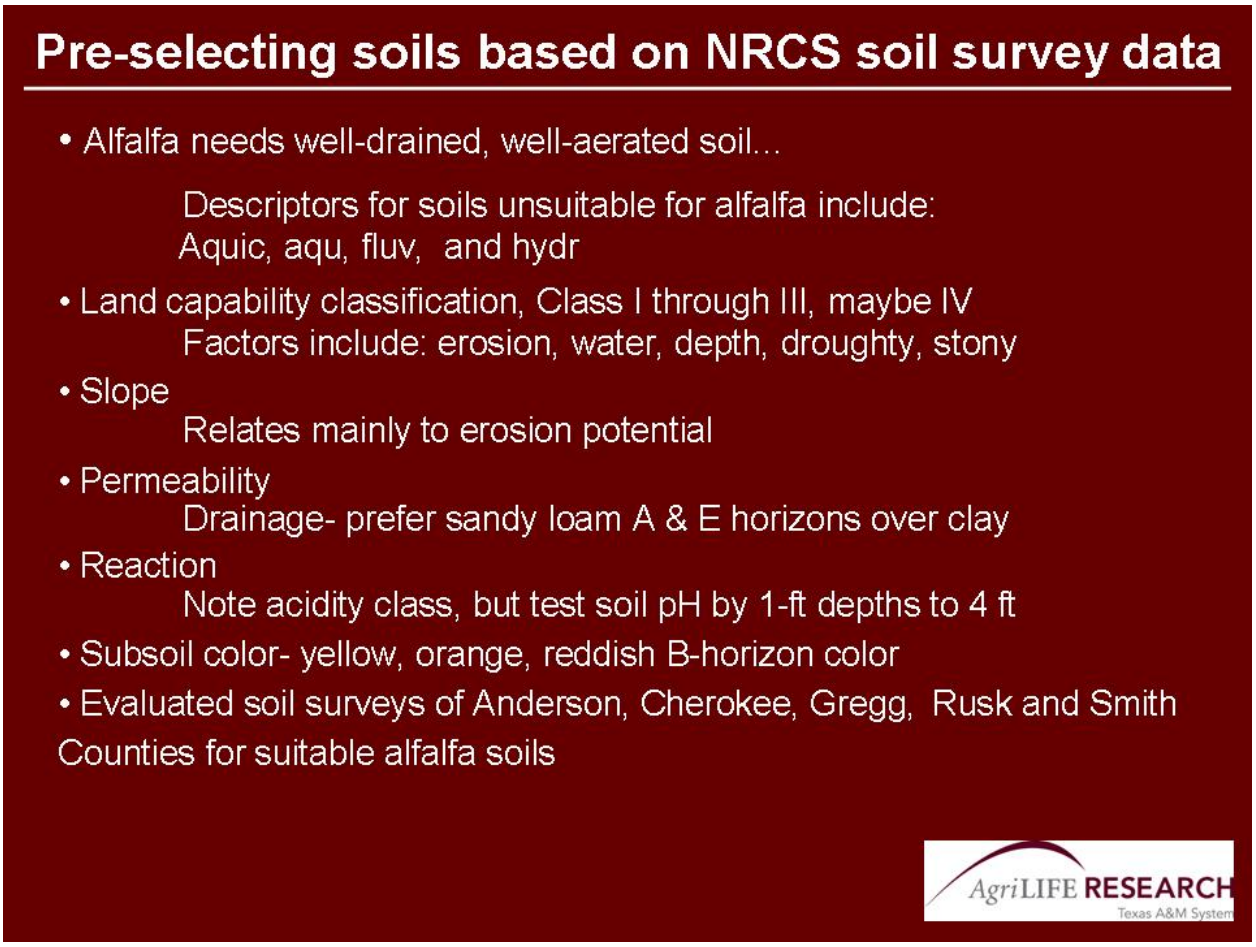
So, for selection of sites for alfalfa on Coastal Plain soils, an additional criterion has been added. Not only must the soil be fertile, well drained and aerated, it also must have a profile pH of 5.5 or higher to at least four feet deep to allow adequate rooting for water uptake during dry periods.

Included in one of the objectives of our SARE-funded study was a survey of soils for their suitability for alfalfa production. This survey combined the known site selection criteria for successful production of alfalfa with soil classification data in the Natural Resources Conservation Service (NRCS) soil survey reports and now at http://websoilsurvey.nrcs.usda.gov/app/. Soil properties considered when pre-selecting soils based on NRCS soil survey data are shown below:



Descriptors that indicate poor drainage and aeration are those that indicate wetness such as aquic, aqu, fluv, and hydr. Examples are Fine, mixed, active, thermic Aquic Hapludults to describe the Sacul soil, and Fine-silty, siliceous, thermic Fluvaquentic Eutrochrept to describe the Laneville loam soil. Each of these contains one or more of the descriptors for excess soil wetness. The description, Loamy, siliceous, semiactive, thermic Grossarenic Paleudults for the Darco soil contains none of the descriptors for excessive wetness so this soil is considered well drained.

Land capability classifications from I to III, or maybe IV, indicate that a site will not be excessively stony, erodible, droughty, or wet and that it has adequate depth for crop production. Numbers are provided that indicate the range of slope for each soil. Slopes greater than 4 to 5% should be avoided for clean-till seeding of alfalfa as these will be susceptible to erosion during stand establishment. Permeability of a soil may be described as slowly permeable, moderately permeable, and possibly excessively permeable. Slowly permeable soils could remain excessively wet for alfalfa.

Preference on Coastal Plain soils should be given to sandy loam A and E horizons over light colored clay. Studies indicate that Paleudults and Paleudalfs may be better suited for alfalfa on Coastal Plain soils than are Hapludults and Hapludalfs, but both have worked well when alfalfa was properly managed.

When soil classification factors indicate that a site may be suitable for alfalfa, sampling the soil to four-feet deep by one foot depths and analysis of these samples for pH, and aluminum if needed, must be done to select soils with a pH of 5.5 or greater to avoid problems with aluminum and possibly manganese toxicity. When sampling, notice the color of the B-horizon clay. Alfalfa will do well on soils having yellow, orange, or reddish clay in this zone of accumulation. Color of all horizons including the clay B-horizon also is stated in the description of the soil given in the NRCS Soil Survey Reports or in the in internet soil survey.

Coastal Plain soils with good potential for sustainable alfalfa production in five counties surrounding Texas A&M- Overton

Anderson Co.	Cherokee Co.	Gregg Co.	Rusk Co.	Smith Co.
Bowie IIe 1-3	Boswell III 3-8	Bowie IIIe 2-5	Betis IIIs 1-5	Bowie IIIe 1-5
Darco, IIIs 1-8	Bowie II-III 1-8	Kirvin IIIe 2-5	Bowie IIe 1-4	Elrose IIIe 3-8
Elrose IIIe 1-8	Eustis III-IV 3-8	Lilbert IIIe 2-5	Darco IIIs 1-8	Gallime IIIe 1-5
Fuquay, IIIe 0-8	Lakeland III-IV 3-8		Kirvin III-IVe 2-5	Lilbert IVe 1-6
Larue, IIIe 3-8	Ruston II-III 1-8		Latex IIe 1-3	Oakwood IIIe 1-5
			Lilbert IIIe 2-5	Picton IIIs 1-6
			Sawtown IIe 0-2	Wolfpen IIIs 1-6
			Ulto IIe 1-3	

Five potentially suitable soils for alfalfa were found in Anderson and Cherokee Counties, three in Gregg, eight in Rusk, and seven in Smith County. Of the soils listed, alfalfa has done well on Bowie, Darco, and Lilbert, all of which are Paleudults, and on a Kirvin that, even though it is a Hapludult, had a history of adequate limestone application so that the subsoil pH was above 6.0 to at least four feet deep. Other soils listed should do equally well if the pH of the soil profile is 5.5 or greater. These soils predominantly are Paleudults, Paleudalfs, Hapludults, and Hapludalfs, with one or more Kandiudults, Quartzipsamments, and Glossudalfs. These soils should be sampled to four feet by one-foot depths and analyzed for pH. If the depth sample pH values are above 5.5, these soils should be suitable for alfalfa.

Coastal Plain soils with limited potential for sustainable alfalfa production in five counties surrounding Texas A&M- Overton

Anderson Co.	Cherokee Co.	Gregg Co.	Rusk Co.	Smith Co.
Arenosa IVs 1-8	Bibb V 0-1	Cuthbert VIe 8-25	Cuthbert VIe 5-15	Cuthbert VIe 5-20
Kaufman Vw FF	Boswell VII 8-15	Iuka Vw FF	Darco VI 8-15	Kirvin IIIe 1-5
Kirvin IVe 3-8	Bub VI-VII 8-40	Iuka I-V 0-1	Kirvin VIe 5-15	Mantachie Vw FF
Nahatche VIw PD	Cuthbert VI-VII 8-15	Kirvin III-IVe 2-8	Laneville Vw FF	Picton Vw FF
Sacul VIe slope	Eustis VII 8-15	Kullit IIe 1-3	Maben IVe 5-15	Redsprings IVe 2-5
Thenas Vw FF	Iuka I-V 0-1	Latch IIIw 0-1	Mattex Vw FF	Redsprings VIe 8-25
Trawick VIe MStp	Hannahatchee I-V 0-1	Mantachie Vw FF	Redsprings VIe 5-15	Tenaha VIe 8-20
Trinity Vw FF	Lakeland IV-VII 5-12	Urbo Vw FF	Sacul IIIe 1-3	Wolfpen VIe 8-15
	Magnolia III-VII 3-15		Sawlit IIw 0-2	
	Nacogdoches III-VII 3-15		Woodtell VIe 5-15	

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More soils in each county were determined to be not suitable for alfalfa than were considered suitable. The unsuitability of these soils is determined by factors such as excessive slope, frequent flooding, excessive wetness, and a high capability classification number. Some listed soils appear good for alfalfa based on the capability classification and slope, but the soil descriptors indicate the soil is too wet (poor to somewhat poor drainage). Soils that fit this description include Iuka in Cherokee and Gregg Counties and the Sacul in Rusk County. The Trawick soil in Anderson County and the Kirvin soil in Gregg County are on the unsuitable list, but sites that contained

these soils with only a slight slope and subsoil pH at or above 5.5 to four feet deep produced good alfalfa when this forage was properly managed in the SARE study. The same criteria used to evaluate soils in these Texas Counties can be applied to Coastal Plain soils in other Texas Counties and across the southern states to determine their suitability for production of sustainable alfalfa. Soils used for on-ranch alfalfa production (shown in the following chart) in the SARE project were selected based on subsoil color and four-foot depth pH above 5.5. Excellent alfalfa growth occurred on all soils. Harvest management was the main factor that determined the four-year average yield on each site.

Major soil series on which alfalfa was grown on four ranches†

Ranch	Soil series	Taxonomic class	4-yr avg. yield, 12% moisture hay, t/ac
1	Kirvin very fine sandy loam	Fine-mixed, semiactive, thermic Typic Hapludults	**4.65**
2	Bowie fine sandy loam	Fine-loamy, siliceous, semiactive, thermic Plinthic Paleudults	**5.18**
3	Bowie fine sandy loam	Fine-loamy, siliceous, semiactive, thermic Plinthic Paleudults	**4.43**
4	Trawick fine sandy loam	Fine-mixed, active, thermic Mollic Hapludalfs	**3.80**

†Alfalfa drowned in the 2nd season at Ranch 5 on a Laneville loam; Fine-silty, siliceous, thermic Fluvaquentic Eutrochrept

As is indicated in the above chart, a fifth ranch was initially involved in this SARE project. The selected site in a creek bottom contained Laneville loam (Fine-silty, siliceous, thermic Fluvaquentic Eutrochrept). On-site sampling at this location indicated that the sand color to four feet was not gray and pH was above 5.5 to the four-foot depth, so the decision was made to use this site as one of the SARE on-ranch alfalfa production evaluation sites. However, alfalfa drowned the second season because of excess soil water from high rainfall. Had the soil description from the Soil Survey Report been used in the site selection process, this site would not have been picked for alfalfa. Descriptors for this soil include Fluv and aqu, both of which indicate an excessively wet soil. So, this alfalfa site selection system using soil survey data and depth pH above 5.5 to four feet can be used on the Coastal Plain to evaluate soil suitability for production of alfalfa.

How we use this system to help potential alfalfa growers determine if their soils will support sustainable alfalfa production on Coastal Plain soils…

When a potential alfalfa grower calls:

- Request latitude and longitude of potential site
- Suggest grower locate site using Google Earth, mark center of property, record Latitude & Longitude and then send L & L by email
- Initiate Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/
  - Click on Latitude and Longitude
  - Click on "Use Degrees/Minutes/Seconds"
  - Enter degrees, minutes, and seconds in boxes
  - Click "View"
  - Click AOI, then place rectangle over noted area
  - Click "Soil Map" at upper left to determine soils available on site
  - Note soil name/s, then http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdnamequery.cgi
  - Enter series name and click "Process"
  - Click "View Description" and look for indicators for wetness, slope, etc.
- If descriptors indicate soil is suitable for alfalfa, ask grower to collect soil samples to at least four feet by one foot depths and submit these to lab for pH analysis.
- If pH $\geq 5.5_{(1:2\ \text{Soil: water})}$, the site should support sustainable alfalfa.

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