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Steps to Successful No-till Establishment of Forages

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No-till seeding means planting forage crops directly into a field with no additional tillage performed after harvesting the previous crop (usually corn, soybean or small grain). No-till seeding also encompasses methods to renovate and/or reseed pastures without tillage.

No-till plays a key role in carbon sequestration. Carbon sequestration is storing carbon from the air into the soil. One of the key roles in sequestering more carbon into the soil is tillage management. There are several methods of tillage in forage production — conventional till (moldboard plow), minimum till, ridge till and no-till. Among these tillage practices, no-till has a greater potential than other tillage methods to store more carbon in the soil. Organic matter helps hold soil nutrients in place so they are not lost to runoff, erosion and leaching. If left undisturbed over the period, soil organic matter can eventually be transformed into long-lasting humus. If the soil is tilled, however, soil organic matter will be oxidized by soil microbial activity and the carbon will be lost to the atmosphere as carbon dioxide.

What are the advantages of no-till in forage production? Firstly, no-till maintains a lot of crop residue that provides a significant amount of organic matter to the soil. Crop residues on the soil surface will reduce topsoil degradation, surface runoff and soil erosion. Secondly, no-till makes more stable soil aggregates that increase water- and nutrient-holding capacity and result in potentially better crop production. In particular, no-till increases microaggregate stability, which contributes to the higher biological activity in the soil than under conventional tillage. Thirdly, no-till will significantly increase earthworm and biological populations (particularly fungi) that contribute to better soil physical properties.

Improving a pasture by no-till seeding legumes into a grass sod.

In summary, no-till forage establishment improves soil and air quality, minimizes surface runoff and soil erosion, enhances water quality, and reduces contributions to the greenhouse gases effect, particularly carbon dioxide. An additional economic benefit is savings in fossil fuel costs due to reduced equipment use.

Conditions that favor no-till seeding include sloping or highly erosive soils, timeliness in planting, energy savings, stony soils and access to a no-till drill. No-till seeding favors moisture conservation. No-till seeding for pasture renovation allows for preservation of some to all of the existing desirable sod grasses, reduced erosion, greater renovation-year forage yields and often less weed encroachment than conventional tillage prior to seeding.

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Though no-till was perceived in the past as being more risky, studies conducted at Michigan State University comparing conventional clear seeding (no cover crop) with no-till seeding of alfalfa 45 days after planting in the spring showed that clear-seeded plots had a slightly higher alfalfa plant density, but the difference disappeared by fall (Table 1). Research in Wisconsin comparing several different planting methods including no-till (Table 2) showed no difference in alfalfa yield or plant density. Minnesota data (Table 3) indicated that red clover consistently yielded more during the establishment year than alfalfa when no-tilled into grass sod suppressed with glyphosate, and higher seeding rates (16 lb / A) of alfalfa were required to maximize alfalfa establishment via no-till. Other Minnesota work demonstrated that over a 4-year period after no-till drilling legumes into a suppressed grass sod, each additional ton of forage associated with pasture renovation cost only around $10 per ton to produce, considerably less than the cost to purchase the same amount of forage as hay (Cuomo et al., 1999). These data, along with producer experiences with no-till seeding in the three-state area, validate the use of no-till establishment as a viable alternative to conventional seeding in forage establishment and pasture renovation.

Table 1. Effect of establishment method on alfalfa plant density and forage yield.

Establishment method	Plant density, first year		Forage dry matter	
	June 19	November 20	First-year total	Second-year cut 1
	-----plants/ft²-----		-----tons/acre-----	
Conventional	19	12	3.8	2.8
No-till	12	12	3.4	2.8

Table 2. Effect of tillage method on first-year alfalfa yield and plant density.
(Data from Dan Undersander, University of Wisconsin.)

Tillage	Year	Yield	Stand 30 to 60 days (plants/yd²)	Stand Oct.23 (plants/yd²)
1. DK/IH	1990	2.87	282	348
2. Chisel	1990	2.90	271	272
3. Moldboard	1990	2.80	265	338
4. No-till	1990	2.58	282	304
1. DK/IH	1991	2.52	252	220
2. Chisel	1991	2.44	103	228
3. Moldboard	1991	2.68	138	236
4. No-till	1991	2.82	223	236
There were no significant differences between no-till and other tillage methods for plant density and alfalfa yields.				

Treatments consisted of (1) disk, seed with IH grain drill, (2) chisel and seed with Brillion seeder, (3) moldboard plow, disk and seed with Brillion seeder and cultipack, and (4) seed with Lilliston no-till drill.

Table 3. Red clover and alfalfa yields during the no-till establishment year as influenced by seeding rate and glyphosate rate into a grass sod in Minnesota (average of two locations).
(Data from Sheaffer and Swanson, U. of Minnesota).

		Rate of glyphosate	
Legume	Seeding rate	0.5 lb a.i./ac	1.5 lb a.i./ac
	Lb/ac	Tons DM/acre	
Red clover	4	1.7	2.9
	8	1.6	3.1
	12	2.1	3.0
	16	2.0	3.0
Alfalfa	4	0.5	1.2
	8	0.7	1.3
	12	0.7	1.4
	16	1.0	1.9

The steps given in this publication should help ensure good stands using no-till establishment. Good stands are necessary for up to 5-ton or larger yields per acre on many sandy loam and loam soils and 6 or more tons per acre on the most fertile, well-drained soils. If naturally well-drained or tiled, all soil management groups (soil classes 1 to 5) and all textures are suitable for no-till establishment and production of alfalfa and other forage crops such as cool-and warm-season grasses and other legume crops.

An established field of alfalfa showing significant stand decline caused from poor internal soil drainage. The use of tile drainage or selection of another species such as birdsfoot trefoil would be appropriate in this situation.

Alfalfa Autotoxicity Considerations

Autotoxicity in alfalfa is a process in which established alfalfa plants produce chemicals that escape into the soil and reduce establishment and growth of adjacent new alfalfa. Negative effects of autotoxicity can remain in the field even after the plants are killed and inhibit growth of the new alfalfa if it is planted too soon after the death of the old stand. The main effect of alfalfa autotoxicity is reduced development of the seedling taproot.

Results for no-till alfalfa are similar to those for alfalfa established using conventional tillage with modern drills.

Seedings affected by autotoxicity can be more susceptible to other stress factors, including seedling disease, insects and environmental conditions. Though autotoxicity does not always cause stand failure, surviving stands may have suppressed yield and plant density (called "autoconditioning") compared with normal stands. Research has shown chronic autosuppression caused by autotoxicity to result in reductions in alfalfa plant density and yield for at least three years after seeding. The best known way to avoid autotoxicity is to use adequate rotation intervals for reseeding alfalfa after alfalfa. Though the recommended rotation interval varies, the general consensus is that at least **one year between alfalfa crops is necessary** to reduce or eliminate the harmful effects of autotoxicity in alfalfa. Thinning alfalfa stands can be no-till seeded via drilling or frost seeding with red clover and / or grasses to maintain as legume stands or convert to pasture.

Drills and Drill Components for No-till Establishment of Forages

Planting conditions for direct-drill seeding are not as uniform as in conventionally tilled fields with a prepared seedbed, but planting objectives are the same. The drill must open a seed furrow, place the seed at approximately ¼ to ¾ inch deep, and cover and firm the soil over the seed. Conventional drills are designed to sow into tilled, uniform soil conditions. No-till drills can operate in tilled fields but are designed for tougher conditions such as sods and firmly compacted, uneven or residue-covered soils. For no-till establishment of small-seeded legumes or grasses, the drill is the most important piece of equipment you will use. It must be adjusted correctly and be equipped with coulters, openers and press wheels that will work together to handle the planting conditions on your farm.

No-till drills are heavier than conventional drills. Major components of no-till drills are the coulters, furrow openers and press wheels. These drills have large, heavy frames designed to perform well in rough fields and hold additional weight to help drive the coulters and openers into the ground. In tough direct-drill seeding conditions, weight can be added for good residue cutting and opener penetration.

Planting 1 inch deep or greater is a main cause of stand failure. Adding spacers to the lift cylinders can improve depth control and prevent planting too deep in tilled soils.

Downward pressure is adjustable according to field conditions. The weight of the drill is transferred to the cutting coulters and the opener assembly through the pressure springs or rubber buffers. The pressure springs or rubber buffers maintain pressure on the coulters for residue cutting and soil penetration yet allow the coulter to trip and reset if it encounters rocks or other obstructions. If the residue is not cut cleanly, it may bunch up in front of the furrow opener and plug the drill, or the residue may get pinched into the bottom of the seed furrow.

Lime should be spread one year prior to planting.

If the residue is pinched into the seed furrow and the seed is placed on top of the residue, seed-soil contact will be poor. The seed may germinate if moisture is available, but the residue will interfere with root development and emergence will be spotty. Residue pinching is most likely to occur when the residue from the previous crop is not evenly distributed and heavy or tough residue covers moist or loose soil. Making sure the residue from the previous harvest is spread evenly over the field can help solve problems with residue pinning. After small-grain harvest, it is best to bale and remove the straw or harvest with a combine equipped with a chaff spreader to improve planting conditions. In heavy residue cover, drills perform best when the residue is dry.

Furrow Openers

Three types of furrow openers are commonly used on disk drills: double-disk openers, single-disk openers and offset double-disk openers. Double-disk openers create a nice seed furrow and are durable in stony ground. Single-disk openers require a little less down pressure for soil penetration than double disk openers. Because they attack the soil at a sharper angle than double disks, they disturb less soil than double-disk openers. Offset double-disk openers combine a single smooth coulter mounted parallel to the direction of travel with a single-disk opener mounted a few inches off-center to the rear of the smooth coulter. The smooth coulter cuts the residue; the angled disk opens the furrow. Less soil is disturbed than with a double-disk opener. Boot openers have horizontal wings at the bottom of the opener to cut roots, loosen soil and create a cavity for the seed at the bottom of the seed furrow.

Fluted coulters are used for cutting through crop residue.

Depth Adjustments for Coulters and Openers

Coulter depth adjustments vary among drills. Depth adjustments usually involve moving clips to increase pressure on the opener rod pressure rings or adjusting the depth rod on the gauge-press wheel assembly. Depth control is not as precise with no-till drills as with row-crop planters, unless the drills have depth control bands on the furrow opener similar to those on a row crop planter. When planting condi-

Seed opener and press wheel.

A no-till drill with fluted coulters for ease in cutting through crop residue.

Fluted coulters need to be adjusted for downward pressure for proper zone tillage.

Adjust downward pressure of press wheels for good soil-seed contact.

tions are good, the coulters can be set to run at the depth of seed placement. As long as the residue is being cut, the furrow opener will be able to place the seed near the desired depth, but the actual depth will vary with soil conditions — placement will be shallower in hard soils and deeper in soft soils. If the soil is not being thrown out of the seed furrow, the cutting coulter can be set deeper than the desired depth of seed placement. Running the coulters deeper may provide more loose soil for seed coverage but may cause even more soil to be thrown from the furrow.

The key to coulter depth is to check seed location behind the press wheels. Measure the amount of soil covering the seed, not the depth from the seed to the surface of the undisturbed soil. It is usually difficult to place seed through the disk opener shallower than ¾ inch, which may be too deep for small-seeded crops such as alfalfa. One possible solution when drilling small-seeded crops is to redirect the drop tubes to place the seed in the tilled soil directly in front of the press wheels rather than dropping the seed through the furrow opener. The press wheels then firm the small seeds into the tilled soil.

Press Wheels

Press wheels help provide good seed-soil contact by pushing seed into the furrow, closing the furrow and firming soil over the seed. Press wheels improve emergence in all conditions and greatly improve emergence in dry conditions. Press wheels will do a better job than a cultipacker of firming the seed furrow in direct-drill systems. The press wheels should match the need of the forage crop and the amount of soil loosened.

In tilled fields, dry, loose soil requires more packing than damp, cohesive soil. No-till and sod seeding, where little soil is tilled, requires more concentrated packing than seeding in loose soil. Some press wheels simply firm the soil that remains in the seed furrow; others actively move soil into the seed furrow. Rubber press wheels flex as they roll over the ground. This allows them to shed sticky, damp soil, which can build up on rigid press wheels. Narrow press wheels increase pressure over the seed. Wider press wheels decrease pressure over the seed but are unlikely to push seed too deep in soft soil. The dual 1-inch, V-configured press wheels firm the soil from the sides and actively move loose soil over the seed furrow. This leaves the soil directly over the seed furrow loose and slightly elevated and helps prevent water puddling and soil crusting over the seed furrow. This type of press wheel could dig in or bury small seeds in soft soil.

Some of the most valuable time spent in no-till seeding forages is the time spent off the tractor checking seed placement, seed coverage and soil firming. Be prepared to experiment and make whatever changes and adjustments are necessary to get the job done right.

Weed Management

No-till seeding systems, like other seeding methods, require perennial weeds to be controlled prior to establishment. Management of annual weeds following row crops or small grains can be accomplished with selective herbicides.

The major benefits of weed control in new seedings are improved forage quality in the first harvest and insurance against stand loss from intense weed competition. Weeds should be controlled during the first 60 days after emergence to prevent loss of stands. In conventional tillage, weeds present at planting are killed by tillage during final seedbed preparation. With no-till seeding, vegetation control must be done with herbicides.

Annual weed control is accomplished before planting with burndown herbicides such as paraquat or glyphosate products. The required rate varies with weed species and size. Refer to the product labels for details. Glyphosate products are preferred if perennial weeds are present. Fields with serious perennial weed problems should not be no-till planted with forage grass or legume crops.

Perennial weeds should be controlled in the previous crop or in the fall before a spring seeding. Herbicide options in the fall include glyphosate products, 2,4-D amine, or a combination of a glyphosate product plus 2,4-D amine. Do not apply 2,4-D amine in the spring prior to spring planting.

The need for a burndown herbicide depends on the presence of weeds at planting time. If no weeds are present, a burndown herbicide is not needed. Previous studies in Michigan, Minnesota and Wisconsin have shown that using herbicides at planting and subsequent selective post-emergence herbicides can significantly increase the alfalfa percentage and forage quality in the first harvest (Table 5) if weeds are present at planting time, regardless of species or size. All of the herbicides listed for postemergence application can be used in all tillage systems, including no-till seeding. A limited number of selective post-emergence herbicides are available for no-till alfalfa. Herbicide use recommendations for no-till establishment of forages can be found in the “Weed Control Guide for Field Crops”, Extension bulletin E-434 (for Michigan), or “Pest Management in Field Crops”, A3646 (Wisconsin), or “Cultural and Chemical Weed Control in Field Crops”, BU-03157 (Minnesota).

Table 5. Forage yield and composition of no-till alfalfa as affected by herbicides.

	First year						Second year	
	Cut 1		Cut 2		Cut 3		Cut 1	
Herbicide	Total forage	Alfalfa	Total forage	Alfalfa	Total forage	Alfalfa	Total forage	Alfalfa
	Tons/A	**%**	**Tons/A**	**%**	**Tons/A**	**%**	**Tons/A**	**%**
None	2.4	18	0.9	65	0.5	94	2.6	92
Paraquat	1.5	57	1.2	68	0.6	89	2.8	86
Paraquat + 2,4-DB	1.4	92	1.4	62	0.8	97	2.8	97

No-till Seeding into Existing Pastures

Often it may not be necessary to destroy an existing pasture with herbicides, especially if it is comprised of preferred grasses. When interseeding with either grasses or legumes, it is important to select species such as red clover, perennial and annual ryegrass, festulolium and orchardgrass, which have some tolerance to shading — existing pasture species will compete for sunlight and shade new seedlings. Close grazing of pastures in the previous fall followed by early spring interseeding and rotational grazing will help reduce competition from the existing sod. Legume and grass species that work well with interseeding include Italian ryegrass, perennial ryegrass, orchardgrass and red clover. Interseeding often will help to fill in thin stands in pastures.

Some Minnesota research demonstrated the importance of sod suppression in achieving acceptable stands of legumes during pasture renovation (Table 6). Even the slow developing Kura clover established as long as a suppression rate of glyphosate was used prior to no-till drilling.

Close grazing in the fall and early spring prior to no-till seeding, together with hoof traffic during the first 5 to 7 days after seeding, can often provide good establishment of legumes such as red clover and grasses such as perennial ryegrass with good seedling vigor. When no-tilling slower establishing species into grass sods, however, using a suppression rate of glyphosate will improve establishment success rate.

Table 6. Influence of sod suppression with glyphosate (0.55 lb a.i./A) on establishment of legumes in grass pasture in western Minnesota (averaged over 2 years, two sampling dates and four no-till planting methods) *(Cuomo et al., 2001)*.

	Sod suppression	No suppression
	Percent stand	
Alfalfa	52	4
Birdsfoot trefoil	33	0
Kura clover	25	1
Red clover	42	2
LSD (0.05)	3.6	

Seeding Dates

Alfalfa, grasses and other legumes can be seeded in April when soil moisture is conducive for planter operation. Seeding the legumes in the summer is another alternative. Most forage legumes should be planted by August 1 in northern regions and August 15 in southern regions (Figure 1). Forage grasses can be seeded in either the spring or summer. Late summer seeding of forage grasses is often more

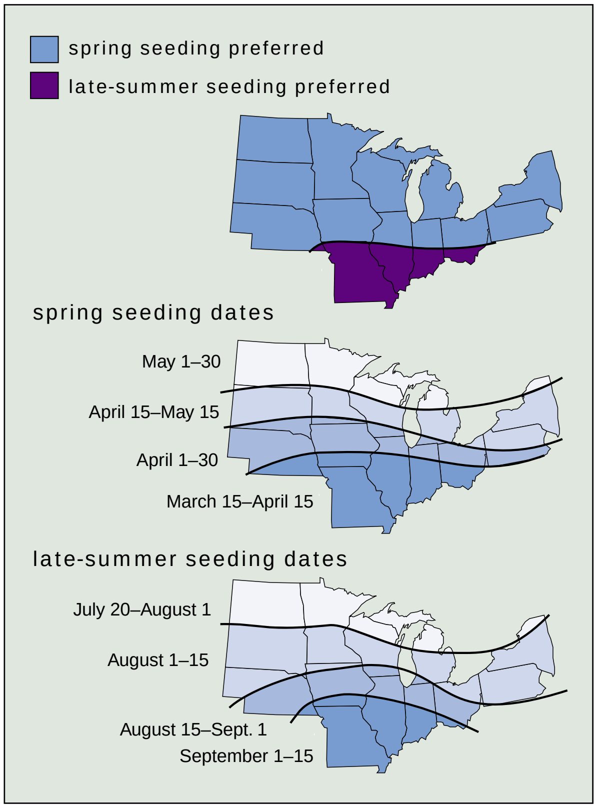

Figure 1. Preferred seeding dates for legumes.

successful than spring seedings because there is less weed pressure at this time and soils are warm and conducive for quick germination. Summer-seeded grasses should be planted by August 15 in northern areas and by September 1 in southern regions (Figure 2).

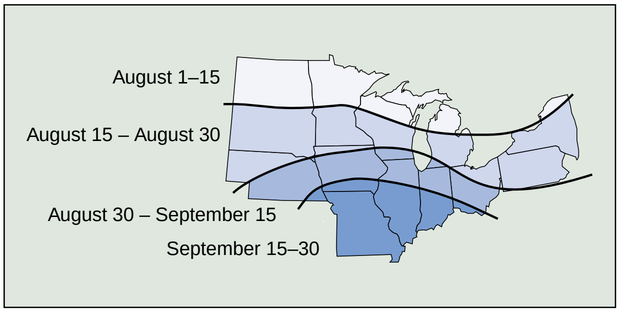

Figure 2. Preferred late summer seeding dates for grasses.

Seeding Rates and Species

Some forage species are better suited to certain soil types than others. For example, alfalfa has an optimum soil pH of 6.8 but will grow at soil pH 6.0 with reduced yield. Birdsfoot trefoil, red clover, ladino or white clover, however, have an optimum soil pH of 6 to 6.2 and will grow at soil pH 5.5 with reduced yield. It is often too difficult or expensive to change soil characteristics such as pH or poor drainage, but changing species is an easy solution with little or no expense. Matching forage species to soil characteristics not only makes establishment easier but also improves production over the life of the stand (see Table 7).

Refer to Michigan State University Extension bulletin E-2307 for more information on forage species and their adaptability to Midwest conditions or to "Forage Variety Update for Wisconsin", A 1525. The same information can be obtained from the following Web sites from Michigan State University — <**http://www.msue.msu.edu/fis/links.htm**> — and the University of Wisconsin <**http://www.uwex.edu/ces/forage/**>.

Table 7. Forage species tolerance to soil and environmental limitations.

Crop	Seedling Vigor	Droughty	Wet	Low pH (below 6.0.)	Winter hardiness
Alfalfa	Moderate	High	Low	Low	Moderate-high
Birdsfoot trefoil	Low	Moderate	High	High	Moderate
Red clover	High	Low	Moderate	Moderate	High
Ladino clover	Moderate	Low	High	Moderate	High
White clover	Moderate	Low	High	Moderate	High
Kura clover	Low	Low	Moderate-high	Moderate	High
Festulolium	High	Low	Moderate	Moderate	Moderate
Italian ryegrass	High	Moderate	High	Moderate	Low
Kentucky bluegrass	Moderate	Low	High	Moderate	High
Orchardgrass	High	Moderate	Moderate	Moderate	High
Perennial ryegrass	High	Low	Moderate	Moderate	Low
Reed canarygrass	Low	High	High	High	High
Smooth bromegrass	High	High	Moderate	Moderate	High
Tall fescue	High	Moderate	Moderate	High	Moderate-high
Timothy	Moderate	Low	Moderate	Moderate	High

Table 8. Seeding rates, depths and times for direct drilling forage crops.

Crop	Seeding rate per acre (lb) Alone	or in a mixture	Depth (inches)	Planting date
Alfalfa	12-16	8-12	1/2	Spring or summer
Birdsfoot trefoil	8	6	1/2	Spring
Ladino clover	2	1	1/2	Spring or summer
Red clover	8 -10	6	1/2	Spring or summer
Kura Clover	6	4	1/2	Spring
Smooth bromegrass	12	6	1/2	Spring or summer
Orchardgrass	10	2-4	1/2	Spring or summer
Timothy	6-8	2-4	1/2	Spring or summer
Perennial ryegrass	20-30	2-10	1/2	Spring or summer
Italian ryegrass	20-30	2-10	1/2	Spring
Reed canarygrass	6-8	6	1/2	Spring or summer
Festulolium	20-30	4-10	1/2	Spring or summer
Tall fescue	15	6	1/2	Spring or summer
Sorghum X Sudan hybrid	20		1-2	May 15-June 15
Turnip	2	—	1/2	May 15-July 15
Rape	5		1/2-1	May 15-July 15

Seeding rates for new stands for either hay or pasture are given in Table 8. Seeding rates for no-till seeding are similar to rates for conventional drilling of forages. In general, seeding rates for single species are heavier because there is no competition between forage species. However, when seeding grasses with legumes, the seeding rate of the grass species is usually reduced to minimize competition with the legume species. This allows the legume to persist longer.

Table 9. Effect of seed lot on seed flow through planters.
(Data from Dan Undersander, University of Wisconsin.)

Calibrate Seeder		
Variety/ lot	Brillion seeder	John Deere drill
1	18.3	21.4
2	17.0	20.3
3	15.0	16.3
4	13.8	16.3
5	20.8	16.5
6	20.3	16.8

Drill Calibration

Calibration of drills is important to ensure stand success. Seed lots vary considerably in size and seeding rates (see Table 9).

You should calibrate the drill even if the same variety is being seeded but year and / or lot of seed has changed. Seed coatings can be quite variable between seed lots. Follow the drill manufacturer's procedures for drill calibration or Table 10 to obtain an accurate seeding rate. Table 10 provides a handy reference chart to be used in drill calibration prior to planting.

Table 10. Seeding rate calibration chart for 7-inch row width drills.

Lb. / A.	Lb./ ft.	Oz. / 100 ft.
8	0.00011	0.17
10	0.00013	0.21
12	0.00016	0.26
14	0.00019	0.30
16	0.00021	0.34
18	0.00024	0.38
20	0.00027	0.43

A no-till planter showing seed openers and steel press wheels.

A diet scale is an inexpensive and effective tool for calibrating seeding rates and can be purchased at grocery stores and pharmacies for generally less than $10. It can save many dollars by preventing over- or under-seeding with expensive forage seed.

Soil Testing and Fertilizer Requirements

Take soil samples after harvest in the fall or before planting in the spring. Fall sampling is preferred if lime applications are anticipated. Other advantages of fall sampling include dry soil (soils are normally drier in the fall than in the spring) and lead time for planning and fertilizer purchase. Soil samples taken in the spring usually test higher than fall samples, so keep the sampling time the same from year to year for long-term comparisons. Fields should be tested every three years. The first step in sampling is to size up the field to be sampled by asking the following questions: Will the field be farmed as a single unit? Are there any features that would lead you to believe that a portion of the field has received different treatments in the past, such as liming treatments, manure rates or management practices? What are the different soil types in the area? Are there any small areas that should be avoided while collecting soil samples?

Sample distribution usually depends on the degree of variability in a given area. In relatively uniform areas smaller than 20 acres, a composite sample of 20 cores taken in a random or zigzag manner is usually

Interseeding into an existing pasture to improve stand density (note bare areas in the pasture.)

sufficient. Larger areas are usually subdivided into smaller units. Use soil survey manuals to help you determine types within fields. Check with your soil-testing laboratory to determine its requirements for sample size.


Legume establishment into wheat stubble using a no-till planter.

Soil testing equipment includes a map of the soil, a notebook for marking and keeping track of samples, a sampling tool and a clean plastic pail for sample collection. Areas of a field that should be avoided or sampled separately include waterways, fencerows or lanes, straw or brush piles, fertilizer bands, sandy ridges and potholes, and dead or back furrows.

Once the 20 samples are taken, mix the samples thoroughly in a pail before putting a composite sample into a soil test box to send to the laboratory. If you need to dry the samples before submitting them to the laboratory, air dry them rather than subject samples to heat.

Non-uniform areas should be subdivided on the basis of obvious differences such as slope position or soil type. Soil samples used for nutrient recommendations should be taken to a depth of 6 inches. When nitrogen fertilizer is on the surface of no-till fields for a number of years, the top layer may be more acid than the lower part of the profile. It is suggested that two separate samples from a field be taken for analysis, one from the top to be used for soil pH and lime requirement only, and the other from the entire soil profile to be used for P and K recommendations. For more information on soil sampling procedures, contact your local Extension office and ask for a publication on sampling soils for fertilizer and lime recommendations.

Cattle grazing in pastures with soils low in magnesium may be prone to grass tetany. When lime is needed on these soils, consider using dolomitic limestone, which will provide additional magnesium.

When selecting a liming material, it is important to understand differences between them. Lime is calcium oxide. However, in agriculture, "lime" is any Ca or Mg compound capable of neutralizing soil acidity. "Lime requirement" is the amount of material needed to increase the soil pH to a particular point or reduce soluble aluminum.


A no-till drill with coil tine and sod-slicing Baker Boot opener without a disc coulter used in overseeding pastures.

Collect 20 cores in a random manner and place into a plastic bucket for mixing.

"Neutralizing value" or "calcium carbonate equivalent" compares a liming material to pure calcium carbonate. Calcite is pure calcium carbonate and contains 40 percent calcium. Dolomite is a mixture of calcium and magnesium carbonate and contains 21.6 percent calcium and 13.1 percent magnesium. Analyses of limestone materials range widely. There are no clear standards for the term "calcitic or dolomitic limestone". Generally, if a liming material is greater than 2 percent magnesium, it is called dolomitic limestone; otherwise it is called calcitic limestone. Most liming materials are mixtures of calcium and magnesium carbonate. Neutralizing value is usually variable between 65 and 95 percent. Marl is a soft, unconsolidated deposit of calcium carbonate. It is very wet and needs to be stockpiled to dry before spreading. Its neutralizing value is between 70 and 90 percent. Other materials used in liming include slag from the iron industry, fly ash from coal burning plants, sludge from water treatment plants, flue dust from cement plants, lime from sugar beet processing plants and lime from paper mills. These liming materials are usually calcitic and are usually quite effective.

Several factors are important in selecting a liming material. Cost and availability are important. Magnesium may be necessary if the soil tests low in this element. Dolomitic limestone should be used if a soil test shows less than 75 lbs / acre of magnesium, if the exchangeable K is greater than the exchangeable Mg, or if exchangeable Mg is less than 3 percent of the sum of exchangeable Ca + Mg + K.

Factors that affect reaction time of a liming material include particle size and surface area or porosity of the material. If the liming material source is one that reacts slowly, you must allow more time before growing a pH-

Collect soil cores with a sampling device like this step-in soil probe.

sensitive crop such as alfalfa. Most states require lime that is sold to be labeled to give the percentage passing 8-, 60- and 100-mesh screens. The fineness factor multiplied by the neutralizing value gives a measurement called effective calcium carbonate. Although this value is not required for labeling in Michigan, it is in many other states. Most legumes are sensitive to soil acidity and will not persist under acid soil conditions. If lime is required, it should be applied at least 6 months before direct drilling. Limited research at Michigan State University, Pennsylvania State University and the University of Minnesota has shown surface-applied lime can give beneficial results if applied at least 6 months ahead of seeding. Liming to the proper pH on sandier soils low in phosphorus is critical to stand establishment success. The maximum amount of lime applied should be no more than 6 tons/acre in one season and no more than 4 tons/acre in one application. Suspending lime in water — referred to as fluid lime — is another approach to lime application. Very finely ground lime materials are mixed in a 50/50 mix of water and liming material and spread using spray nozzles. Consequently only a small amount of lime can be applied at a time. The finely divided lime reacts quickly with the soil so that very low pH soils can be corrected quickly.

Banding phosphorus at planting can be very beneficial, according to MSU alfalfa research in Michigan, but most drills are no longer equipped with band seeders, so phosphorus should be broadcast prior to planting and according to soil test recommendations. Apply fertilizer as recommended by the soil test to bring soil nutrient levels to proper levels. If the field has received manure applications during the previous crop, fertilizers may not be needed, but only a soil test can accurately measure soil nutrient levels and prevent poor forage establishment as a result of improper soil fertility.

Insect Control. Insect damage to grass forages during establishment is generally not a concern, but insect feeding can devastate legume forages, especially alfalfa. Potato leafhopper is the primary insect of concern. Potato leafhoppers can reduce the vigor and later performance of alfalfa seedings. Proper monitoring and control when the economic threshold has been reached are extremely important during alfalfa establishment. When alfalfa is direct drilled into old sods, grasshoppers can be especially destructive to new seedings during a dry spell. For more information on insect control in forages, refer to MSU Extension bulletin E-1582, "Insect and Nematode Control in Field and Forage Crops", available from the MSU Bulletin Office, Michigan State University, East Lansing, MI 48824 ($3).

Red clover successfully established into a grass pasture.

Managing the New Seeding

Pastures that have been interseeded can be grazed periodically, but avoid close grazing of legumes. Several grazing cycles actually help in legume establishment by reducing competition from the grasses. Observe the new seedings a few weeks after planting to note progress of growth and make changes in grazing or clipping that aid in establishment. For new seedings into killed sods, allow the legume to begin blooming prior to grazing — this will allow plants to develop deep roots and prevent pulling of plants by grazing animals. In contrast, no-till seedings into suppressed sods need to be "flash" or mob grazed before the existing sod completely overtops the developing seedlings to reduce competition. This mob grazing is best done with a 1- to 3-day grazing period. It should be delayed if soil moisture is high to reduce damage to developing seedlings. Producers are often fearful of damaging new seedlings by early grazing during pasture renovation, but if grazing is managed properly, far fewer seedlings will be damaged by grazing than by excess competition from the existing sod. New seedings can be harvested for hay or haylage approximately 60 days after plants emerge. This will ensure adequate carbohydrate root reserves develop in the roots and crowns. If weeds become a problem, they can be controlled either with a herbicide or early harvest.

No-till planting into row crop or small grain stubble usually results in better stands than planting into old sod.

New seedings of legumes and grasses should be rested from September 15 through October 15 to allow the plants to store carbohydrates and proteins in their root systems. Perennial ryegrasses do not need the rest period. They should also be grazed short (less than 4 inches) going into the winter to reduce disease pressure and winterkill.

Follow with top-dress fertilization as indicated by soil test results. As a general rule, alfalfa, clovers and birdsfoot trefoil and cool-season grasses will remove 60 pounds of potash per ton harvested. Grazing animals recycle nearly 90 percent of the fertilizer back into a pasture. Managed rotational principles — including high density stocking rates, limited grazing time and access to water in each paddock — ensure good distribution of manure and even forage consumption. If stocking rates are low or water sources are too far away, uneven distribution of manure will occur with subsequent poor distribution of plant nutrients.

Sampling soil.

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