Table 3. Aglime requirement based on soil pH, reactive Al, and target pH.

Soil pH[1]	Reactive Al	Target pH	
		6.8	6.2
	ppm	tons / acre	
>6.7		0	0
6.2-6.7	0-40	1	0
	>40	2	0
5.6-6.1	0-40	2	1
	41-70	2.5	1.5
	71-100	3	1.5
	101-150	3.5	2
	151-200	4	2.5
	>200	5	3
<5.6	0-40	3	1.5
	41-70	3.5	2
	71-100	4	2
	101-150	4.5	2.5
	151-200	5	3
	201-250	5.5	3.5
	251-300	6	4
	>300	7	5

[1] Soil pH is reported as the equivalent of pH measured in water (approximately 0.6 higher than pH measured in 0.01 *M* $CaCl_2$).

Nitrogen

Nitrogen for Annual Crops

Most annual nonlegume crops are very responsive to application of N. Table 4 shows recommended N application rates for annual crops (without credit for manure or previous crop). If the previous crop was a perennial forage crop or other legume crop, adjust values by subtracting previous crop N credits in Table 5. If manure has been applied in the past two years, subtract manure N credits calculated from Tables 14 to 17. Nitrogen rates are adjusted based on soil drainage class. Soils with poor or excessive drainage receive higher N recommendations because of the higher potential for gaseous N loss (denitrification) or nitrate leaching and / or slower N release via mineralization. The adjustments for previous crop, applied manure, and soil drainage are attempts to make N recommendations more site-specific, but they are estimates based on average weather and soil conditions. For a more reliable recommendation for corn, sidedress N when corn is 12 to 24 inches tall at a rate based on the Presidedress Soil Nitrate Test (PSNT) from a soil sample taken when plants are 8 to 12 inches tall (Table 6).

Nitrogen rates for corn, whether based on a PSNT or on previous crop and manure, are also adjusted for yield level. This is a well-established practice based on the fact that a higher yielding crop takes up more N than a low yielding one. However, evaluation of long-term N response trials on corn in Wisconsin, Iowa, and Pennsylvania has shown poor correlation between yield level and optimum fertilizer N rate. It appears that soil and weather conditions conducive to producing high crop yields are the same conditions that support greater N supply from soils and more efficient use of that N by plants. There is evidence for some variation in optimum N rate based on soil type and climate, resulting in soil yield potential differences. Long-term average yield on a particular soil or field is a better estimate of soil yield potential and optimum N rate than yield goal, or maximum attainable yield, which commonly leads to over-fertilization.

In Vermont we are using a combination of drainage class and a more limited adjustment based on yield level than is used in some states (Table 4). The resulting N recommendation will be more accurate if it is based on a long-term average for the field, rather than a "yield goal" or maximum yield. The best approach is to use the PSNT, which will provide a recommendation based on the specific field conditions in a given year (Table 6).

Following are several application suggestions or adjustments in the recommended N rates:

- Nitrogen rates in Table 4 are total amount of N to apply, both manure and fertilizer, including starter and broadcast or sidedress N. Apply a portion of the recommended N as a starter fertilizer banded with the planter (10-30 lb / acre for corn, 10-20 lb / acre for winter small grains, 10-30 lb / acre for spring small grains). Use the higher rates where no pre-plant N or manure has been applied. Subtract starter N rate to determine application rate for broadcast or sidedressing. (For more information, see UVM Extension Br 1392, *Starter Fertilizer for Corn in Vermont*.)
- The salts in fertilizer—primarily N and K compounds—can cause poor germination and seedling injury if excessive rates are applied near the seed. To prevent these problems, limit the rate of starter fertilizer. For corn, limit combined N + K_2O banded with planter (2" to the side and 2" below the seed) to 80 lb / acre.

Table 4. Recommended nitrogen rates for annual crops (without credit for manure or previous crop).

		Soil drainage class		
		Somewhat poorly to poorly drained	Well drained to moderately well drained	Excessively drained
Corn	Expected yield			
	Silage[1] ton / acre / Grain bu / acre	N to apply, lb / acre		
	15 / 90	90	80	90
	20 / 120	120	100	120
	25 / 150	150	130	150
	30 / 180	150[2]	150	150[2]
Small grains (oats, wheat, barley, rye), millet		70	50	70
Sorghum, sorghum-sudan, sudangrass, sunflower		90	70	90
Dry beans, peas, buckwheat		40	30	40
Soybeans		0[3]	0[3]	0[3]

Note: Reduce N rates for previous crop credits (Table 5) and manure application (Tables 14-17).
[1] Silage yields are wet tons / acre (30-35% DM).
[2] 30 ton / acre (180 bu / acre) yield not considered realistic on these soils. Recommendation for 25 ton / acre yield is provided.
[3] A low rate of N (5-10 lb / acre) may be applied in a 2"x2" placed starter band, but do not apply in direct contact with the seed.

For small grains, limit combined N + K_2O applied with the grain drill to 40 lb / acre.

- For no-till corn, add 30 lb / acre to above rates to account for slower N mineralization and / or greater N losses under no-till conditions.
- For corn grown on sandy, excessively drained soils without manure, split nitrogen into pre-plant and / or starter (50 or more lb / acre) with the remainder applied as a sidedress.
- For small grains on fields where lodging tends to be a problem, reduce N rates by 20 lb / acre.
- Soybeans properly inoculated with N-fixing bacteria seldom respond to N fertilizer. Inoculate with fresh, viable bacteria just before planting. If soybeans have not been grown on the field previously, triple the rate of inoculant.

Credit for Previous Crop

Nitrogen released from the previous year's plowed-down crop residue can supply a significant portion of a crop's N need. Nitrogen tied up in the roots and above-ground regrowth of perennial forages, especially legumes, is released over an extended period of time as soil microorganisms break down the plant tissues and release N in inorganic forms that plants can use. Nitrogen credits

Table 5. Nitrogen credits for previous crops.

Previous crop		Fertilizer N credit	
		Previous year	Two years ago
		lb / acre	
Alfalfa	>60% legume	120	60
	20-60%	80	40
Red clover, trefoil	>60% legume	90	40
	20-60%	70	30
Grass	Moderate-high level mgmt. (>2 ton / acre yield	70	30
	Low level mgmt. (2 ton / acre or less)	40	20
Soybeans, dry beans / peas		30	0

Note: Subtract N credit from recommended N rates in Table

Table 6. Recommended nitrogen rates for corn based on the Pre-sidedress Soil Nitrate Test (PSNT).

PSNT	Expected corn yield[1]		
	15 ton / acre or 90 bu / acre	20 ton / acre or 120 bu / acre	25+ ton / acre or 150+ bu / acre
ppm	N to apply, lb / acre[2]		
2	80	110	140
4	80	110	140
6	80	105	135
8	75	100	125
10	70	90	115
12	65	80	100
14	60	75	90
16	55	65	80
18	50	60	70
20	45	50	60
22	40	40	45
24	35	35	35
25	30	30	30
26	0	0	0

[1] Silage yields are wet tons / acre (30-35% DM).
[2] If previous crop was a well-managed stand of grass, legume, or mixed forage, subtract 30 lb / acre from above N rates.

for the first and second year after plowdown (Table 5) should be subtracted from the N rates given in Table 4. Because the amount of N released varies with temperature and moisture conditions, as well as the amount and type of initial plant material, the values in Table 5 are estimates and will vary for the specific situation. Use of the PSNT is the best way to reduce this uncertainty when corn is the current crop (Table 6).

Pre-sidedress Soil Nitrate Test (PSNT) for Corn

Until recently, there was no reliable soil test for N in the more humid eastern part of the U.S., and N recommendations were based only on yield goals and average soil and weather conditions. (See Tables 4 and 5.) But with the development of the PSNT by Dr. Fred Magdoff of the University of Vermont, we now have such a tool. The PSNT requires a soil sample (0 to 12 inch depth) taken when plants are 8 to 12 inches tall. Nitrate measured at that time is a good indicator of the N-supplying capacity of the soil, accounting for soil differences among fields and year-to-year weather differences in the same field. Fertilizer N is then recommended to supply adequate N to the corn crop. Applying fertilizer N at sidedress time is also a more efficient use of N, especially under conditions for high leaching potential, because it avoids loss of N between spring and the start of the period of maximum crop N demand in late June and July.

Nitrogen rates based on the PSNT range from a maximum rate at PSNT values of 5 or less to zero at PSNT of greater than 25 ppm (Table 6). Because these are sidedress N application rates they do not include N applied in the starter, assuming a 10 to 20 lb / acre rate. Recommendations in Table 6 are based on the following formulas, depending on expected yield (rounded to nearest 5):

15 ton / acre yield: N Rate=80-2.5 x (PSNT-5); except if PSNT <5, then N Rate=80 lb / acre.

20 ton / acre yield: N Rate=110-4 x (PSNT-5); except if PSNT <5, then N Rate=110 lb / acre.

25 ton / acre yield: N Rate=140-5.5 x (PSNT-5); except if PSNT <5, then N Rate=140 lb / acre.

Soil samples for PSNT are taken between corn rows to avoid starter fertilizer bands so they do not measure starter N. Consequently, starter N rates greater than 20 lb / acre should be subtracted from the recommended sidedress rates. Recommended N rates are reduced by 30 lb / acre where previous crop was a well-managed stand of grass, legume, or mixed forage. Recent research results have shown less yield response to N fertilizer where corn followed a good sod plowdown than the PSNT would indicate. Apparently, this is because N mineralization rate increases proportionally more after PSNT sampling where a perennial forage was plowed down than with a previous crop of corn.

Nitrogen for Perennial Forages

Establishment (Seeding Down)

No N is recommended for establishment of legumes or legume-dominant mixtures without a companion crop because N will favor the grasses and weeds and it may delay development of N-fixing capacity of legumes (Table 7). When the perennial forage species is established with a small grain companion crop, or when grasses are direct seeded (i.e., without a companion crop), some N is

Table 7. Recommended nitrogen rates for establishment of perennial legume or grass forages.

Companion or nurse crop	Legumes, legume-grass	Grasses
	—— N to apply, lb / acre ——	
None	0	50[1,2]
Small grain	30	30[2]

[1] For late-summer seeding, reduce to 30 lb / acre.
[2] If a second grass harvest is expected, make a second application of 40-50 lb N / acre after first harvest.

needed to support adequate growth. The higher N rate for direct-seeded grasses is for spring seeding to support a grass harvest later in the season. Nitrogen rate when a companion crop is used must be limited to avoid excessive competition, or even lodging, from the small grain.

Topdressing

Established grass forage species generally show consistent and large yield increases from application of N fertilizer. Economic responses can be obtained from application of as much as 200 lb N / acre on well-managed, high-yielding stands (three- or four-cut system, adequate P and K fertility, etc.). (See Table 8.) For lower level management or yield potential situations, less N is recommended. Because of the potential for leaching and other losses, N should be split into multiple applications of 40 to 75 lb / acre each. An optimum schedule is to apply N before significant regrowth occurs for each crop to be harvested—in early spring and after first, second, and (if a fourth cut will be made) third harvest. The higher rate should be applied in early spring when growth (and N response) potential is the greatest.

If manure is to be applied (or has been applied), reduce fertilizer amounts to account for nutrient contributions from manure (Tables 14 to 17). While manure can provide significant N for a grass crop, volatile losses of N as ammonia can be quite high from surface-applied manure. Consequently, best yields are usually obtained if manure is supplemented with fertilizer N.

Mixed stands with less than 20% legume should be fertilized as grass unless legumes are being encouraged, in which case a reduced rate should be applied in early spring. Stands with higher legume amounts (20 to 60%) may benefit from an early spring topdress of about 40 lb / acre, and in some cases (20 to 40% legume) from a second application later in the season. No N is recommended for hay stands where legumes are dominant (>60%), because N is supplied by N-fixing bacteria.

Table 8. Recommended nitrogen rates for perennial grass and grass-legume forages.

	Nitrogen to apply	
	Per application	Total per year
Grass (<20% legume)[1]	N, lb / acre	
Hay, high level mgmt. (5+ ton / acre)	50-75	200
Hay, medium level (3-4 ton / acre)	50	150
Hay, l ow level mgmt. (2 ton / acre)	40-50	100
Pasture, intensively managed	50	100
Pasture, low-level management	50	50
Conservation planting	40	40
Legume-grass mix (20-60% legume)		
Hay harvest	40	40
Pasture	0	0
Conservation planting	0	0

[1] Yields are dry hay equivalent (12-15% moisture). One ton dry hay is equivalent to 2.5 tons haylage (65% moisture).