NITROGEN RECOMMENDATIONS FOR FIELD CROPS IN NEW YORK

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Picture by Q. M. Ketterings

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1. INTRODUCTION

Nitrogen (N) is an essential and often growth-limiting plant nutrient. Crops take up N that is released to the soil solution as a result of atmospheric deposition, soil organic matter mineralization, crop residue decomposition and animal manure and inorganic fertilizer addition. Furthermore, N may become available through biological fixation.

Only inorganic N, principally nitrate (NO_3^-) and ammonium (NH_4^+) is available for plant growth. Nitrite (NO_2^-) can be taken up but this N form is toxic to plants and is generally present in trace quantities only.

A deficiency in nitrogen leads to yield declines or even a complete crop failure. An excess of nitrogen may lead to excessive vegetative growth, lodging, delayed maturity, increased disease susceptibility, low crop quality and nitrate accumulation. Excesses may contribute to acid rain, destruction of the ozone layer in the stratosphere, the greenhouse effect, eutrophication of our surface waters, contamination of ground water, fish and other marine life kills as well as blue baby syndrome in infants, amphibian mortality and deformations. The nitrate concentration in ground and surface waters is an important water-quality index. The U.S. Environmental Protection Agency (EPA) has set the Federal Standard for the maximum permitted amount of nitrate N in drinking water at 10 mg N per L or 43 mg NO_3^- per L.

It is important from both an economic and an environmental standpoint to manage N optimally. Thus, the two primary objectives of N management are: 1) to have adequate inorganic N available during the growing season; and 2) to minimize the availability of inorganic N during the fall, winter, or early spring, when N may be transported to surface and groundwater.

2. NITROGEN REACTIONS IN SOIL

2.1 Fixation

The atmosphere is about 78% N_2 by volume. This gaseous N is chemically stable and unavailable to most biological organisms. However, some species of bacteria can convert N_2 to N containing organic compounds. This process is called biological fixation and it is the primary mechanism by which atmospheric N_2 is added to the soil. Legumes such as alfalfa and clover have root nodules that contain N-fixing bacteria that convert atmospheric N_2 to protein. The legume, upon its death, will increase the amount of organic N in the soil as decomposition proceeds.

$$\underset{\textit{(nitrogen gas)}}{N_2} \rightarrow \underset{\textit{(ammonia)}}{NH_3} \rightarrow \underset{\textit{(organic nitrogen)}}{R\text{-}NH_2}$$

2.2 Mineralization

Organic N exists in plants, soil organic matter, soil microorganisms, animal manure, etc. When organic N decomposes, it is converted into ammonium. This process, facilitated by microorganisms, is called mineralization. Because ammonium is positively charged, it is generally adsorbed by the negatively charged soil particles that dominate soils. Thus, the ammonium leaching potential is minimal.

$R\text{-}NH_2$	→	NH_3	→	NH_4^+
(organic nitrogen)		*(ammonia)*		*(ammonium)*

2.3 Nitrification

Certain microorganisms in the soil convert ammonium to nitrite and then to nitrate by a process called nitrification. Nitrification occurs rapidly when the soil is moist, warm, and well aerated. These conditions coordinate well with early summer when crop N needs are on the rise. Nitrification will significantly increase soil acidity (decrease pH) by producing H^+ ions. Liming materials may be needed to counteract the added acidity. Nitrification is affected by soil temperature: nitrification rates are virtually zero below 41°F and above 122°F. Optimum temperature range for nitrification is 67-86°F. The nitrifying bacteria require oxygen. Thus, soil drainage and aeration stimulate nitrification. Although ammonium is not very prone to leaching losses, fertilizer-ammonium applications may still lead to large leaching losses because of rapid nitrification.

NH_4^+	→	NO_2^-	→	NO_3^-
(ammonium)		*(nitrite)*		*(nitrate)*

2.4 Denitrification

When there is a depletion of oxygen in the soil, anaerobic bacteria can convert nitrate into gaseous forms of N including nitric oxide gas, nitrous oxide gas, and dinitrogen gas. This process, called denitrification, results in a loss of plant available N from the soil and its return to the atmosphere. Denitrification is accelerated in poorly aerated (<10% oxygen), and/or waterlogged soils. The optimum temperature for denitrification is between 77 and 95°F. Denitrification ceases to take place at temperatures <33°F and >122°F. Dinitrogen gas is environmentally harmless. However, NO and N_2O can contribute to the formation of nitric acid (an important component of acid rain) and contribute to the greenhouse effect. N_2O can furthermore contribute to the destruction of ozone.

NO_3^-	→	NO_2^-	→	NO	→	N_2O	→	N_2
(nitrate)		*(nitrite)*		*(nitric oxide gas)*		*(nitrous oxide gas)*		*(dinitrogen gas)*

2.5 Immobilization

Soil microbes compete with plants for available ammonium and nitrate. Immobilization refers to the process by which inorganic N is bound in the microbial biomass, thus making it unavailable to plants until the microbes die and decompose, in which case the N re-enters the mineralization process. Immobilization and mineralization occur simultaneously in the soil. Whether the net effect is an increase or a decrease in inorganic N depends on which process dominates. A high (>25) carbon to nitrogen ratio of the organic material that is being decomposed may result in a (temporary) net immobilization of N. This may be observed when large amounts of straw or sawdust bedding are included with manure applications. It may also occur when low N containing stubble is tilled into the soil.

$$\begin{array}{ccc} NH_4^+ & & \\ \textit{(ammonium)} & \searrow & \\ & & R\text{-}NH_2 \\ & & \textit{(organic nitrogen)} \\ NO_3^- & \nearrow & \\ \textit{(nitrate)} & & \end{array}$$

2.6 Ammonia Volatilization

Nitrogen can be lost to the atmosphere by volatilization, a process whereby a substance is converted from a solid or liquid to a gas. Typically, N is lost by volatilization of ammonia when urea-containing fertilizers or manure are applied on the soil surface and not incorporated. Little or no ammonia loss occurs from surface applications of acidic fertilizers such as ammonium nitrate or ammonium sulfate, unless the soil pH is very high. Ammonia volatilization increases with increasing soil pH and decreasing moisture content. High temperatures also stimulate volatilization. As much as 50% of the total amount of manure N may be lost if the manure is not incorporated after application.

$$\underset{\textit{(urea)}}{H_2N\text{-}\overset{\overset{O}{||}}{C}\text{-}NH_2} \rightarrow \underset{\textit{(ammonium)}}{NH_4^+} \rightarrow \underset{\textit{(ammonia)}}{NH_3}$$

3. SOURCES OF NITROGEN

There are four main sources of N: 1) native soil organic matter; 2) organic amendments (animal and green manure, compost, plowed under sods); 3) biologically fixed N; and 4) inorganic fertilizer N. To calculate the inorganic N requirement for optimum economic yield, adjustments need to be made for biologically fixed N and/or N released from one or more of the organic sources. Procedures used to estimate N release from plowed under sods and from manure applications are discussed below.

3.1 Soil Organic Matter

Soil organic matter consists of plant and animal residues, living soil organisms, and substances synthesized by these organisms. Organic matter is decomposed by soil microorganisms and results in the release of many essential plant nutrients. Soils in New York can typically supply 40 to 80 pounds of N per acre annually depending on soil type, organic matter content, and previous management. In spite of it's variable nature, soil organic matter is an important source of available N and must be accounted for when determining fertilizer requirements.

The soil's nitrogen supplying capacity (SoilN in lbs N/acre) is a function of soil type and artificial drainage class:

SoilN = N_sup_ud + ((N_sup_dr – N_sup_ud) * (ArtificialDrainage/3))

Where:

N_sup_ud is the amount of N supplied by an undrained soil (lbs N/acre).

N_sup_dr is the amount of N supplied by the same soil with excellent rated artificial drainage (lbs N/acre).

ArtificialDrainage is a factor to adjust soil N supply for field artificial drainage conditions:

If artificial drainage = "none" then ArtificialDrainage = 0
If artificial drainage = "inadequate" then ArtificialDrainage = 1
If artificial drainage = "adequate" then ArtificialDrainage = 2
If artificial drainage = "excellent" then ArtificialDrainage = 3

Table 1 in the Appendix lists estimates of soil N supply for each New York soil type.

3.2 Legumes and Grass Sods

Legumes can, through biological N fixation, acquire enough N to meet their requirements assuming that proper inoculation and nodulation occur. Grasses, including corn, cannot fix atmospheric N and therefore require N addition either supplied by companion legumes, animal or green manures, soil organic matter mineralization or fertilizer application. Nitrogen is bound in the roots and above ground biomass of grasses and legumes. When the legume, grass, or legume/grass sod is killed, the organic N will become available to subsequent crop(s) through mineralization. The amount of N available from these crop residues is a function of the sod density and quality, the percent legume and time since the sod crop was plowed or killed. If a good quality sod is 100% grass, the amount of organic N is estimated to approach 150 lbs/acre. Legumes contribute a greater amount of N because of their greater N content; for good stands with 1-25% legume, the total amount of organic N may reach 200 lbs N/acre. A stand with 26-50% legume will yield approximately 250 lbs N/acre while a >50% legume containing sod is estimated to contain about 300 lbs N/acre.

The N contribution from sod is discounted depending on the number of years since the sod crop was plowed down. Sod crops and their crop code are listed in Table 1. Of the total amount of organic N contained in the sod, 55% is expected to be available to the first crop after plowdown, 12% to the next crop and 5% to the third crop or year. This N contribution reduces the N requirement of subsequent crops accordingly. Thus, 55% or 83 lbs N/acre of an estimated 150 lbs N/acre in a good grass sod is expected to be available to the next crop. No N credits are expected for crops planted more than three years after sod plowdown.

Table 1. Cornell crop codes and descriptions of “sod” crops.

Crop Codes*	Crop Description	Crop Codes*	Crop Description
ABE & ABT	Alfalfa Trefoil Grass	CLE & CLT	Clover
AGE & AGT	Alfalfa Grass	CSE & CST	Clover Seed Production
ALE & ALT	Alfalfa	CVE & CVT	Crownvetch
BCE & BCT	Birdsfoot Trefoil Clover	GIE & GIT	Grasses Intensively Managed
BGE & BGT	Birdsfoot Trefoil Grass	GRE & GRT	Grasses
BSE & BST	Birdsfoot Trefoil Seed	PGE & PGT	Pasture with Improved Grasses
BTE & BTT	Birdsfoot Trefoil	PIT	Pasture Intensively Grazed
CGE & CGT	Clover Grass	PLE & PLT	Pasture with Legumes

* A crop with a crop code ending with an “E” is in its establishment year while an ending with a “T” implies an established sod.

3.3 Manure

There are primarily two forms of N in manure: ammonium N and organic N (Figure 1). The ammonium N is initially present in urine as urea and may account for about 50% of the total N. Urea in manure is no different from urea in commercial fertilizer. It hydrolyzes rapidly to ammonium (a form of inorganic N). In principle, all of the ammonium from urea in manure is available for plant growth. However, parts or all of it may be lost because ammonium is rapidly converted to ammonia as the pH increases and the manure begins to dry. Atmospheric exposure of manure on the barn floor, in the feedlot, in storage, or after spreading increases N loss. Thus, an analysis of the manure is useful to determine how much ammonia may be conserved before spreading. Table 2 shows the fraction of the ammonia N remaining for plant use from various livestock manures given alternative application methods and timing of application.

Table 2: Estimated ammonia-N losses as affected by application method.

Manure Application Method	Ammonia N Utilized by the Crop (%)
Injected during growing season	100
Incorporated within 1 day	65
Incorporated within 2 days	53
Incorporated within 3 days	41
Incorporated within 4 days	29
Incorporated within 5 days	17
No conservation/Injected in fall	0

Picture by Q.M. Ketterings

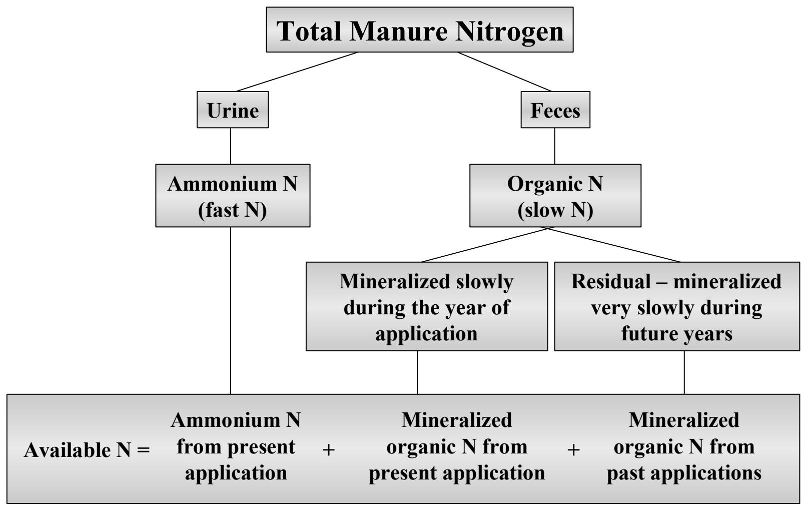

Figure 1: Manure N consists of ammonium and organic N (modified from Klausner, 1997).

Table 3. Decay series for stable organic N in manure by animal type. A "last year release rate" of 12% indicates that an estimated 12% of the organic N applied in the manure is expected to be utilized by the crop a year after application.

		Release rate for organic N in manure (%)		
Source	Dry Matter Content (%)	Present Year "Decay_current"	Last Year "Decay_lastyr"	Two Years Ago "Decay_2yrs"
Cows	<18	35	12	5
Cows	≥18	25	12	5
Poultry	<18	55	12	5
Poultry	≥18	55	12	5
Swine	<18	35	12	5
Swine	≥18	25	12	5
Horses	<18	30	12	5
Horses	≥18	25	12	5
Sheep	<18	35	12	5
Sheep	≥18	25	12	5

The more stable organic N is present in the feces and is only slowly released. The decomposition of stable organic N to a plant available inorganic form occurs at different rates. The less resistant organic N decomposes during the year of application, and the more resistant organic N decomposes very slowly in future years. Repeated application to the same field results in an accumulation of a slow release manure N source. A decay or mineralization series is commonly used to estimate the rate of N availability from stable organic N. A decay series of 35, 12, and 5% is used to estimate the rate of decomposition of organic N in liquid (<18% dry matter) dairy manures in New York. This sequence of numbers means that 35% of the organic N is mineralized and potentially taken up by the growing crop during the year the manure was applied, 12% of the initial organic N application is mineralized and taken up during the second year, and 5% is mineralized and taken up in the third year. There is evidence that manure containing large amounts of bedding may mineralize at a slower rate than fresh manure. Therefore, the estimated availability of N during the year applied is reduced from 35 to 25% when the dry matter content of bedded manure exceeds 18%. These decay series and those for other animal manures are listed in Table 3.

Fertilizer recommendations are adjusted for the release of N from previous years' applications. The following calculations are used to determine the residual manure N contribution (ResidualN_manure):

ResidualN_manure = ResidN1 + ResidN2
ResidN1 = Decay_lastyr * (Organic N/100) * ManureRate_lastyr
ResidN2 = Decay_2yrs * (Organic N/100) * ManureRate_2yrs

Where:

ResidualN_manure is the total residual N from manure (lbs N/acre).
ResidN1 is the residual N from manure applied last year (lbs N/acre).
ResidN2 is the residual N from manure applied two years ago (lbs N/acre).
Decay_lastyr is the organic N decay last year (fraction, see Table 3).
Decay_2yrs is the organic N decay 2 years ago (fraction, see Table 3).
ManureRate_lastyr is the amount of manure applied last year (lbs dry matter/acre).
ManureRate_2yrs is the amount of manure applied 2 years ago (lbs dry matter/acre).
Organic N is the organic N content of the applied manure on an as sampled basis.

4. CALCULATING NITROGEN RECOMMENDATIONS FOR SPECIFIC FIELD CROPS

There is no reliable soil test for N other than the Pre-Sidedress Nitrogen Test (see section 6). Research efforts in the past have focused on the main agronomic crops in New York State (including corn) leading to more site-specific recommendations for these crops than for others (such as buckwheat). Recommendations can be met by inorganic N application or a combination of inorganic and manure application. Independent of how much of the requirement is satisfied with manure or other organic sources that need to be mineralized, for some crops, a minimum inorganic N requirement is recommended for optimal economic yields (Table 4). In the following section, the approach and specific equations for several agronomic crops are outlined.

Table 4: Recommended minimum inorganic N application.

Crop	Recommended minimum inorganic N application (lbs/acre)
Triticale peas (TRP)	40
Grasses:	
Topdressing (GRT)	50
Topdressing intensively managed (GIT)	100
Pastures:	
Native and improved grasses (PNT, PGT)	50
Intensively managed grass (PIT)	90

4.1 Grain corn and corn silage

The N requirements for corn silage and grain corn are identical. Requirements depend on the corn yield potential, nitrogen content of the soil and nitrogen content of sod crops on the field in the past three years adjusted for the soil's specific nitrogen uptake efficiency (ability of that soil to actually deliver N to the crop). For grain corn the equation is:

NetRequiredN = (YP_corngrain*1.2 – SoilN - SodN)/(N_eff/100)

Where:

NetRequiredN is the total amount of N (lbs N/acre) from any source required for optimum crop production.

YP_corngr is the yield potential of corn grain in bushels (85% dry matter) per acre (see Appendix Table 1).

SoilN and SodN are the amounts of N (lbs N/acre) released from mineralization of soil organic matter and a plowed-down sod, respectively (see earlier sections on sod and soil organic matter).

N_eff is the soil type and drainage dependent uptake efficiency (listed for each soil type in Appendix Table 1).

The yield potential for corn is soil type and artificial drainage specific:

YP_corngr = Corngr_ud + (Corngr_dr – Corngr_ud) * (ArtificialDrainage/3)

Where:

Corngr_ud is the expected yield of grain corn (an average over a ten year period in bushels of 85% dry matter grain per acre) grown on this undrained soil under excellent management (see Appendix Table 1).

Corngr_dr is the expected yield of grain corn (bushel/acre) grown on the same soil that has excellent artificial drainage (see Appendix Table 1).

ArtificialDrainage is an adjustment factor for artificial drainage identical to those reported above (soil organic matter section).

Estimated yields are converted to total N per acre assuming that 100 bushels of grain (85% dry matter) equal 10,000 lbs of dry matter (5,000 lbs in grain and 5,000 lbs in stover) and the average N content at optimum yield is 1.2%. For corn silage, the net N requirement is calculated assuming that 17 tons of silage (35% dry matter) equals 100 bushels of grain (85% dry matter). Silage yield potential in tons per acre (35% dry matter) is converted to yield potential in bushels of grain per acre (by multiplying by 5.9) prior to estimation of N requirements.

Plants are not able to take up 100% of the inorganic N supplied to the soil, although 100% efficiency for fertilizer additions and inorganic N from manure can be approached when small quantities are directly delivered to the growing crop (e.g. as sidedress). The percentage of applied fertilizer that does become part of the plant is called the uptake efficiency. The estimates for New York State soils range from 50 to 75 percent (Appendix, Table 1). In general, N uptake efficiencies (N_eff in percentage, see Appendix Table 1) are soil type and artificial drainage class specific:

N_eff = N_eff_ud + (N_eff_dr – N_eff_ud) * (ArtificialDrainage/3)

Where:

N_eff_ud is the estimated percentage of inorganic fertilizer N that is taken up by the corn crop when the soil is left in its original un-drained state.

N_eff_dr is the expected percentage of applied N that is taken up by the plant when the soil is artificially drained.

The amount of N required to obtain the desired yield potential (NetRequiredN in lbs N/acre) can be supplied in the form of inorganic N or a combination of inorganic and manure N. The N requirement is increased by 20 lbs/acre for a no till crop production system due to slower soil warming in the spring.

4.2 Grain sorghum, sorghum forage, sudangrass, sorghum sudan hybrid, and millet

The N requirement for grain sorghum, sorghum forage, sudangrass, sorghum sudan hybrid, and millet is equal to or a fraction of the N requirement for a grain corn crop:

NetRequiredN = (YP_corngr*1.2 – SodN – SoilN)/(N_eff/100)
If NetRequiredN > 50 lbs N/acre then NetRequiredN = NetRequiredN * 0.8

The latter equation indicates that if the net N requirement calculated using the corn yield potential is >50 lbs/acre, it is adjusted to 80% of the corn requirement. The N requirement is increased by 20 lbs/acre for a no till crop production system.

4.3 Stands of alfalfa, alfalfa grass, birdsfoot trefoil, birdsfoot trefoil-clover, and clover-grass

To establish a legume or legume-grass sod, no N is required. Nitrogen requirements for established legume and legume-grass stands (i.e. topdressing) depends on management intensity and on the percentage legume in the sod:

If the stand is 100% grass (0% legume):
NetRequiredN = 75 lbs/acre (1-2 cut system)
NetRequiredN = 125-175 lbs/acre (3-4 cut system)

If the stand is 1 to 25 % legume then NetRequiredN = 40 lbs/acre
If the stand is greater than 25% legume then NetRequiredN = 0 lbs/acre

These recommendations are not adjusted for N releases from previous sods or soil organic matter.

4.4 Wheat, wheat seeded with legume, barley-winter barley-winter with legume, oats, oats with legume, barley-spring, barley-spring with legume, and rye production

The nitrogen recommendations for wheat, wheat seeded with legume, barley-winter barley-winter with legume, oats, oats with legume, barley-spring, barley-spring with legume, and rye production depend on the number of years since sod was grown on this field and the soil management group. If it is less than 1 year ago that a sod was plowed under, the recommended N rate is 20 lbs/acre independent of soil management group because N residual from sod is built into these recommendations. If it was two years or more ago that a sod was plowed down, the recommendations increase (see Table 5). Unlike corn, the recommendations for these crops do not consider the % legume or soil N contributions. Soil_group is the soil management group determined by clay content, the soil rooting depth and the soil structure. Clayey soils tend to fall in group I, while sandy soils tend to be in group V. Most of the silt loam soils of the central plains are group 2's and the silt loam soils of the southern tier are group 3's. Soils in management group 6 are muck soils.

Table 5: N recommendations for small grains following sods.

Soil_group	Sod plowed under <1 year ago	Sod plowed under 1-2 year ago	Sod plowed under >2 years ago
1-4 and 6	20	50	60
5	20	60	70

4.5 Sunflowers

The N requirement for sunflowers is estimated as 66% of the corn N requirement given an average corn yield potential of 120 bushels (85% dry matter) per acre. The N requirement increases by 20 pounds per acre for a no till crop production system. The minimum nitrogen requirement for sunflowers is 30 lbs N/acre.

$$NetRequiredN = \{(YP\_corngr * 1.2 - SodN - SoilN) / (N\_eff/100)\} * 0.66$$

4.6 Other field crops

Nitrogen requirements for all other field crops are constant values (Table 6).

Table 6: Nitrogen requirements for selected field crops.

Crop Name	Crop Code	N Requirement (lbs/acre)
Beans Dry	BDR	0
Buckwheat	BUK	20
Grass-intensive management, establishment phase	GIE	50
Grass-intensive management, established (top-dress)	GIT	225
Grasses, establishment phase	GRE	50
Grasses, established (top-dress)	GRT	75
Idle land	IDL	0
Pasture with improved grasses, establishment phase	PGE	50
Pasture with improved grasses, established (top-dress)	PGT	75
Pasture-rotational grazing, establishment phase	PIE	50
Pasture-rotational grazing, established (top-dress)	PIT	150
Pasture with legumes, establishment phase	PLE	40
Pasture with legumes, established (top-dress)	PLT	40
Pasture with native grasses, established (top-dress)	PNT	75
Rye-cover crop	RYC	20
Soybeans	SOY	20
Triticale/peas	TRP	80
Waterways, pond dikes, establishment phase	WPE	50
Waterways, pond dikes, established (top-dress)	WPT	70

5. NITROGEN FERTILIZERS

Inorganic N requirements can be met using a variety of N containing fertilizers. Table 7 lists fertilizer materials and their N, P_2O_5, K_2O, S, Ca, and Mg contents as well as their salt hazards, acid-forming tendency and additional notes.

Table 7: N, P_2O_5, K_2O, S, Ca, and Mg contents as well as the salt hazard and acid forming tendency of commonly used N containing fertilizers (adapted from Brady and Weil, 1996; Jokela et al., 1999; Beegle, 1996, Cornell Field Crops and Soils Handbook, 1987).

	N	P_2O_5	K_2O	S	Ca	Mg	Salt hazard	CCE*	Additional notes
Ammonium nitrate (NH_4NO_3)	33-34	0	0	0	0	0	high	-59	Dry material. Can be left on surface or incorporated into soil. Absorbs moisture from the air. It can be blended but not with urea. High risk of fire or explosions if mixed with oxidizable forms of C (e.g. fuel oil).
Ammonium sulfate ($[NH_4]_2S0_4$)	20-21	0	0	24	0	0	high	-110	Dry material. Used for direct application and blended fertilizers. Can be left on surface or incorporated into soil. Rapidly lowers the soil pH.
Urea - ammonium nitrate (UAN)	28-32	0	0	0	0	0	medium	-52	Liquid fertilizer. Urea N comprises about 50% of the N. Once applied, UAN behaves as dry urea and NH_4NO_3. To minimize N loss, incorporate into soil. May cause leaf burn. UAN weighs 11-12 lbs per gallon.
Potassium nitrate (KNO_3)	13	0	36	0.2	0.4	0.3	very high	+26	Dry crystalline material. A specialty fertilizer used for direct application or as blended fertilizer.

Table 7 continued: N, P_2O_5, K_2O, S, Ca, and Mg contents as well as the salt hazard and acid forming tendency of commonly used N containing fertilizers (adapted from Brady and Weil, 1996; Jokela et al., 1999; Beegle, 1996, Cornell Field Crops and Soils Handbook, 1987).

	N	P_2O_5	K_2O	S	Ca	Mg	Salt hazard	CCE*	Additional notes
Anhydrous ammonia (NH_3)	82	0	0	0	0	0	low	-148	A high-pressure liquid. It turns into a gas when released. The gas is toxic. Needs pressurized equipment. Must be injected 6-8 inches deep on friable, moist soil to avoid N losses. Weighs about 5 lbs per gallon. Rapidly lowers the soil pH.
Urea (NH_2-CO-NH_2)	45-46	0	0	0	0	0	medium	-84	Dry material that should be incorporated. Urea-N rapidly hydrolyzes to NH_4^+. Used for direct application, in mixed fertilizers, and in liquid nitrogen. Not recommended as a starter.
Sulfur coated urea	30-40	0	0	13-16	0	0	low	-110	Dry material. Variable slow rate of release. Rapidly lowers soil pH.
Mono-ammonium phosphate (MAP) ($NH_4H_2PO_4$)	11-13	48-52	0	1-2			low	-65	A dry material. Used for direct application and in blended fertilizers. Makes an excellent starter fertilizer, either alone or with a small amount of potash although the N:P ratio may be to low for high P soils.
Di-ammonium phosphate (DAP) ($[NH_4]_2HP0_4$	18-21	46-53	0	0-1			medium	-70	A dry material. Used for direct application and in blended fertilizers. Produces free ammonia and is hence not a good starter fertilizer.

* Acid forming tendency expressed as kg $CaCO_3$/100 kg of fertilizer. A positive number indicates an increase in pH upon application. A negative number implies a fertilizer induced decrease in pH.

6. PRE-SIDEDRESS NITROGEN TEST (PSNT)

The pre-sidedress nitrogen test provides a way to determine if there will be enough available nitrogen in the soil for maximum economic yield of corn. The PSNT is the nitrate level of a soil test consisting of the top 12 inches of soil taken when corn is 6 to 12 inches tall. PSNT samples should be dried immediately following sampling to stop further nitrification. If PSNT nitrate results are 25 ppm or above, there is sufficient N in the soil for maximum economic yield so the probability of a response rapidly approaches zero. When results are between 21 and 25 ppm, there is about 10% probability that a yield response would be obtained from additional N. The quantity of N that is needed when the PSNT is below 25 ppm is determined by computing the N requirements considering the soil, crop, rotation, and manure histories as described for corn in previous sections but subtracting any fertilizer N applied pre-plant or at planting.

Picture by Q.M. Ketterings

7. Nitrate Leaching Index[1]

The Nitrate Leaching Index (LI) is an estimate of the average annual percolation expressed in inches for a particular location. The LI is based on the concept that a soil's leaching potential increases as rainfall increases. The extent of the increase depends on soil drainage characteristics. For a given annual rainfall amount, excessively well drained soils such as Howard, Adams, Hoosic, Suncook and Tunkhannock, or even the well drained soils such as Bath, Madrid, Honeoye and Ontario have a significantly greater leaching potential than poorly drained soils such as Vergennes, Swanton, Rhinebeck, Lordstown or Volusia. The current LI rates leaching potential based on soil hydrologic group and rainfall data from weather stations around NY.

The Nitrate Leaching Index is a multiplication of the Percolation Index and the Seasonal Index (Williams and Kissel, 1991):

LI = Percolation Index * Seasonal Index

The Percolation Index (PI) is calculated for each hydrologic soil group. The hydrologic codes for all New York State soils can be found in Appendix Table 1. Soils with a hydrologic code "A" have the greatest percolation while soils of hydrologic code "D" have the least percolation and are therefore least conducive to leaching.

For soil with a hydrologic code "A":

$$PI = (PA - 10.28)^2 / (PA + 15.43)$$

For soil with a hydrologic code "B":

$$PI = (PA - 15.05)^2 / (PA + 22.57)$$

For soil with a hydrologic code "C":

$$PI = (PA - 19.53)^2 / (PA + 29.29)$$

For soil with a hydrologic code "D":

$$PI = (PA - 22.67)^2 / (PA + 34.00)$$

PA is the annual average precipitation in inches (see Appendix Table 3 for county-based, annual precipitation data). For soils that a hydrologic code that consists of more than one letter (e.g. "A/B", "B/C", "C/D"), its hydrologic code is determined by the presence or absence of adequate artificial drainage. If the field is artificially drained (ArtificialDrainage = "adequate" or "excellent") the hydrologic group moves to the first of the two classes. If the field is inadequately drained or not drained at all,

[1] An article by K.J. Czymmek, Q.M. Ketterings and H. van Es published in What's Cropping Up? volume 11 no 5 formed the basis for this section.

(ArtificialDrainage = "none" or "inadequate"), the second of the two classes is assigned. For example, a Halcott soil has a hydrologic class of "C/D". If this soil has adequate or excellent artificial drainage, the hydrologic code used is "C". If the soil is not or inadequately artificially drained, the hydrologic code "D" is assigned. For soils with a single hydrologic code in Appendix Table 1, the artificial drainage does not have an impact on the hydrologic code used.

The Seasonal Index (SI) is determined by the annual precipitation (PA in inches) and the sum of fall and winter precipitation (PW, from October though March in inches): $SI = (2 * PW/PA)^{1/3}$ (Williams and Kissel, 1991). County-based values for both can be found in Appendix Table 3.

An LI below 2 inches indicates that the potential for nitrate leaching below the root zone is low. A LI greater than 10 inches indicates that the potential for soluble nutrient leaching below the root zone is large while LI's between 2 and 10 are considered intermediate. In order to meet the requirements of the NRCS nutrient management standard (590) for N leaching, producers are expected to *implement* appropriate best management practices if the LI score for a field is high (>10). Producers are expected to *consider* the same practices on a case-by-case basis if the LI score for a field is intermediate (2-10). Best management practices recommended for soils with a medium to high N leaching indices are:

- Unless the New York Phosphorus Index identifies the need for P based fertility management, manure and fertilizer application rates can be based on Cornell guidelines for meeting crop N needs.
- For corn, pre-plant (other than starter fertilizer) and early post plant *broadcast* applications of commercial nitrogen without the use of nitrification inhibitors are not recommended.
- Sidedress applications should be made after the corn has at least four true leaves.
- If starter N must be broadcast (e.g., for small grains or new seedings of grass), apply fertilizer as close to expected planting date as possible (ideally within 3 days or less).
- For row and cereal crops, including corn, maintain starter fertilizer N rates below 50 lbs/acre actual N under normal conditions.
- Manure and fertilizer applications should be adjusted based on information provided in this publication.
- Evaluate the need for sidedress N applications based on PSNT or other soil nitrate-nitrogen tests.
- Sod crops should not be incorporated in the fall. Chemical sod killing may be carried out when the soil temperature at a 4 inches depth is approaching 45^oF. Depending on location, this will not likely take place until early October.
- Minimize fall and/or winter manure application on good grass and/or legume sod fields that are to be rotated the following spring.
- Appropriate ammonia conservation is encouraged. Losses can either be reduced by immediately incorporating manure or eliminated by directly injecting manure as a sidedress application to growing crops.

- Plant winter hardy cover crops whenever possible, regardless of, but especially when fall manure is applied (e.g., rye, winter wheat, or interseed ryegrass in summer).
- Manure may be applied in the fall where there is a growing crop. Judicious amounts of manure can be applied to or in conjunction with perennial crops or winter hardy cover crops. Applications should generally not exceed the greater of 50 lbs/ace of first year available N or 50% of the expected N requirement of next year's crop.
- Frost incorporation/injection is acceptable when soil conditions are suitable (See Cornell Cooperative Extension, 2001, page 21 "Frost Tillage"), but winter applications should be made in accordance with the New York Phosphorus Index.
- Manure N application on legumes is acceptable to satisfy agronomic requirements when legumes represent less than 50% of the stand. When legumes represent more than 50% of the stand, manure may be applied at a rate not exceeding 150 lbs of available N/acre.

Picture by Q.M. Ketterings

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APPENDIX

Table 1: Soil management group (SMG), Hydrologic code (HC), inorganic nitrogen uptake efficiencies (N-Eff in %), soil N supply (N-Sup, in lbs N/acre) and corn yield potential (YP in bushels/acre) for undrained (UD) and artificially drained (DR) New York soils. General characteristics of the soil management groups are given in Table 2.

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
ACTON	4	C	65	70	65	65	120	125
ADAMS	5	A	70	70	40	40	95	95
ADIRONDACK	4	D	75	75	70	70	75	75
ADJIDAUMO	1	D	55	60	65	75	75	105
ADRIAN	6	A/D	55	65	90	120	60	120
AGAWAM	4	B	75	75	65	65	140	140
ALBIA	3	C	60	65	60	70	100	120
ALBRIGHTS	2	C	70	70	75	75	110	120
ALDEN	3	D	50	60	65	80	65	90
ALLAGASH	5	B	75	75	65	65	105	105
ALLARD	3	B	75	75	70	70	135	135
ALLENDALE	3	D	55	60	60	70	80	100
ALLIS	3	D	60	65	65	75	80	100
ALLUVIAL LAND	3	C	60	65	70	75	75	100
ALMOND	3	C	60	65	65	75	90	95
ALPS	3	C	70	70	75	75	110	115
ALTMAR	5	B	65	70	50	60	100	115
ALTON	5	A	75	75	65	65	125	125
AMBOY	4	C	75	75	60	60	140	140
AMENIA	4	B	70	70	65	65	135	140
ANGOLA	2	C	60	65	70	80	95	110
APPLETON	2	C	60	65	65	75	105	125
ARKPORT	4	B	75	75	50	50	125	125
ARMAGH	2	D	55	60	70	80	80	100
ARNOT	3	C/D	70	70	70	70	90	100
ASHVILLE	3	D	50	55	65	75	75	95
ATHERTON	3	B	55	60	55	75	90	105
ATKINS	3	D	50	60	65	75	70	105
ATSION	5	C	60	65	60	70	70	95
AU GRES	5	B	55	65	60	65	90	100
AURELIE	3	D	55	60	70	80	75	95
AURORA	2	C	70	70	70	70	110	115
BARBOUR	3	B	75	75	75	75	140	140
BARCELONA	3	C	60	65	65	75	90	115
BARRE	1	D	55	65	70	80	80	105

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
BASH	3	C	60	65	65	75	105	130
BASHER	3	B	70	70	70	70	140	140
BATH	3	C	75	75	75	75	125	125
BECKET	4	C	75	75	60	60	100	100
BECRAFT	3	B	70	70	75	75	150	150
BELGRADE	3	B	70	70	80	80	140	145
BENSON	4	D	70	70	65	65	80	80
BERKSHIRE	5	B	75	75	65	65	125	125
BERNARDSTON	4	C	75	75	65	65	135	135
BERRIEN	5	C	70	70	55	55	120	120
BERRYLAND	5	B	50	60	70	75	60	90
BESEMAN	6	A	50	65	90	130	60	130
BICE	5	B	75	75	65	65	130	130
BIDDEFORD	2	D	50	60	70	75	65	95
BIRDSALL	3	D	50	55	70	75	70	90
BLASDELL	3	A	75	75	70	70	125	125
BOMBAY	4	B	70	70	65	65	135	135
BONAPARTE	4	A	70	70	50	50	100	100
BONO	1	D	50	60	70	80	60	100
BOOTS	6	A	55	65	90	130	60	130
BOROSAPRISTS	6	A/D	55	65	90	140	60	150
BOYNTON	3	D	55	65	70	75	80	100
BRACEVILLE	4	C	70	70	75	75	115	120
BRAYTON	4	C	60	65	70	70	90	105
BRIDGEHAMPTON	3	B	70	70	70	70	150	150
BRIDPORT	2	D	60	65	65	75	105	120
BRIGGS	4	A	75	75	60	60	100	100
BRINKERTON	2	D	55	65	70	80	80	100
BROADALBIN	4	C	75	75	65	65	130	130
BROCKPORT	1	D	60	65	70	80	95	120
BROOKFIELD	3	B	75	75	75	75	130	130
BUCKLAND	3	C	70	70	70	70	90	90
BUCKSPORT	6	D	55	65	90	140	60	150
BUDD	4	B	75	75	40	40	105	105
BURDETT	2	C	60	65	70	80	100	120
BURNHAM	3	D	60	65	70	80	70	95
BUSTI	3	C	60	65	60	70	100	120
BUXTON	2	C	70	70	70	70	120	120
CAMBRIA	2	D	55	60	65	75	80	105
CAMBRIDGE	3	C	70	70	70	70	120	125
CAMILLUS	3	B	70	70	75	75	120	125
CAMRODEN	3	C	60	65	70	75	100	110

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
CANAAN	4	C	70	70	65	65	75	75
CANAAN-ROCK OUTCROP	4	C	70	70	65	65	75	75
CANADICE	2	D	55	65	60	70	80	110
CANANDAIGUA	3	D	55	65	70	80	90	110
CANASERAGA	3	C	70	70	80	80	125	125
CANASTOTA	2	C	70	70	75	75	120	125
CANEADEA	2	D	60	65	65	75	105	120
CANFIELD	3	C	70	70	75	75	115	120
CANTON	4	B	75	75	60	60	130	130
CARBONDALE	6	A	55	65	90	130	60	130
CARLISLE	6	A/D	55	65	90	130	60	130
CARROLLTON	3	C	75	75	75	75	105	105
CARVER	5	A	70	70	40	40	75	75
CARVER-PLYMOUTH	5	A	70	70	40	40	75	75
CASTILE	4	B	75	75	75	75	135	135
CATHRO	6	A	55	65	90	140	60	150
CATHRO-GREENWOOD	6	A	55	65	90	140	60	150
CATTARAUGUS	3	C	75	75	75	75	125	125
CAVODE	2	C	60	65	70	75	105	120
CAYUGA	2	C	70	70	75	75	135	135
CAZENOVIA	2	B	70	75	75	75	135	135
CERESCO	3	B	70	70	75	75	145	145
CHADAKOIN	3	B	75	75	75	75	130	130
CHAGRIN	3	B	75	75	75	75	140	140
CHAMPLAIN	5	A	70	70	50	50	75	75
CHARLES	3	C	55	60	70	80	75	90
CHARLTON	4	B	75	75	65	65	130	130
CHATFIELD	4	B	70	70	50	50	100	100
CHATFIELD	4	B	70	70	65	65	100	100
CHAUMONT	1	D	55	65	65	75	80	100
CHAUTAUQUA	3	C	70	70	75	75	125	125
CHEEKTOWAGA	5	D	55	65	55	75	80	105
CHENANGO	3	A	70	70	70	70	130	130
CHESHIRE	4	B	75	75	75	75	125	125
CHIPPENY	6	D	55	65	90	130	60	130
CHIPPEWA	3	D	55	65	70	75	80	100
CHURCHVILLE	2	D	60	65	70	80	105	120
CICERO	2	C	60	65	70	75	100	115
CLARKSON	2	B	70	70	75	75	135	140
CLAVERACK	4	C	70	70	70	70	120	120

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
CLYMER	4	B	75	75	70	70	110	120
COHOCTAH	4	B	55	65	70	80	80	100
COLLAMER	3	C	70	70	75	75	140	140
COLONIE	5	A	70	70	50	50	105	105
COLOSSE	4	A	70	70	50	50	70	70
COLRAIN	4	A	75	75	65	65	130	130
COLTON	5	A	70	70	50	50	85	85
COLWOOD	3	D	55	65	70	80	90	110
CONESUS	2	B	70	70	75	75	135	140
CONOTTON	3	A	75	75	70	70	125	125
CONSTABLE	5	A	70	70	50	50	75	75
COOK	5	D	50	60	70	80	70	90
COPAKE	4	B	75	75	65	65	135	135
CORNISH	3	C	60	65	65	75	95	110
COSAD	4	C	60	70	60	70	105	120
COSSAYUNA	4	C	75	75	65	65	135	135
COVERT	4	A	70	70	60	60	115	120
COVEYTOWN	4	C	65	70	65	75	90	110
COVINGTON	1	D	55	60	70	75	75	95
CRARY	4	C	65	70	60	70	110	120
CROGHAN	5	B	70	70	50	50	100	100
CULVERS	3	C	70	70	75	75	115	125
DALBO	3	C	70	70	75	75	95	115
DALTON	3	C	60	65	70	75	95	105
DANLEY	2	C	70	70	75	75	120	125
DANNEMORA	4	D	55	65	65	75	75	90
DARIEN	2	C	60	65	70	75	100	115
DAWSON	6	A	55	65	90	140	60	150
DEERFIELD	5	B	70	70	60	65	105	110
DEFORD	4	A	55	60	65	75	75	100
DEKALB	4	A	75	75	70	70	100	100
DEPEYSTER	3	C	70	70	75	75	140	140
DEPOSIT	3	B	70	70	75	75	125	130
DERB	3	C	60	65	70	75	95	115
DIXMONT	5	C	70	70	65	65	115	120
DORVAL	6	A	55	65	90	140	60	150
DOVER	4	B	75	75	70	70	125	125
DUANE	4	B	70	70	60	60	95	95
DUNKIRK	3	B	75	75	75	75	140	140
DUTCHESS	4	B	75	75	65	65	135	135
DUXBURY	4	A	75	75	65	65	95	95

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
EDWARDS	6	B	55	65	90	130	60	130
EEL	2	B	65	70	75	75	140	140
EELWEIR	4	C	70	70	50	50	130	135
ELKA	4	C	75	75	70	70	115	115
ELLERY	3	D	55	65	70	75	80	100
ELMRIDGE	5	C	70	70	60	60	135	135
ELMWOOD	4	C	70	70	60	60	130	130
ELNORA	5	B	70	70	50	50	110	110
EMPEYVILLE	4	C	70	70	60	60	100	105
ENFIELD	3	B	75	75	75	75	150	150
ENSLEY	3	B	55	60	65	75	75	95
ERIE	3	C	60	65	65	75	95	115
ERNEST	3	C	75	75	75	75	75	75
ESSEX	5	C	75	75	70	70	95	95
FAHEY	5	B	70	70	55	65	100	100
FARMINGTON	3	C	75	75	65	65	90	90
FARNHAM	4	C	70	70	70	70	120	125
FERNLAKE	4	A	70	70	60	60	75	75
FONDA	2	D	50	60	70	80	70	100
FREDON	4	C	55	65	70	75	90	115
FREETOWN	6	D	50	65	90	130	60	130
FREMONT	2	C	60	65	65	75	100	110
FRENCHTOWN	3	D	55	60	65	75	70	105
FREWSBURG	3	C	60	65	65	75	80	95
FRYEBURG	3	B	75	75	70	70	95	95
GAGE	3	D	55	60	65	75	90	95
GALEN	4	B	70	70	60	60	130	130
GALESTOWN	5	A	70	70	40	40	90	90
GALOO	4	C	70	70	50	50	75	75
GALOO-ROCK OUTCROP	4	C	70	70	50	50	75	75
GALWAY	4	B	75	75	70	70	130	130
GENESEE	2	B	75	75	80	80	155	155
GEORGIA	4	C	70	70	75	75	135	140
GETZVILLE	3	D	55	60	65	75	75	90
GILPEN	3	C	75	75	75	75	120	120
GILPIN	3	C	75	75	70	70	110	110
GLEBE	4	C	70	70	70	70	75	75
GLEBE-SADDLEBACK	4	C	70	70	70	70	75	75
GLENDORA	4	A/D	75	75	70	70	75	75
GLENFIELD	3	B	50	60	65	75	90	110

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
GLOUCESTER	4	A	70	70	50	50	120	120
GLOVER	4	D	70	70	60	60	90	90
GOUGEVILLE	5	A	50	60	65	75	75	100
GRANBY	5	A/D	55	60	60	65	75	100
GRATTAN	5	A	70	70	50	50	105	105
GREENE	3	C	60	65	65	75	90	110
GREENWOOD	6	A	50	65	90	140	60	150
GRENVILLE	4	B	75	75	75	75	140	140
GRETOR	3	C	60	65	65	75	75	90
GROTON	4	A	70	70	70	70	105	110
GROVETON	4	A	70	70	65	65	95	95
GUFF	1	D	50	55	60	75	75	90
GUFFIN	1	D	50	60	60	65	60	75
GULF	4	B	55	60	65	75	75	90
HADLEY	3	B	75	75	70	70	140	140
HAIGHTS	3	B	60	70	50	60	95	100
HAIGHTS-GULF	3	B	60	70	50	60	95	100
HAILESBORO	3	C	60	65	65	75	110	125
HALCOTT	2	C/D	70	70	75	75	75	80
HALSEY	4	C/D	50	60	70	75	90	100
HAMLIN	2	B	75	75	80	80	155	155
HAMPLAIN	2	B	75	75	80	80	150	150
HANNAWA	4	D	55	60	60	70	85	100
HARTLAND	4	B	75	75	75	75	155	155
HAVEN	4	B	75	75	65	65	150	150
HAWKSNEST	3	C/D	70	70	75	75	75	80
HEMPSTEAD	4	B	75	75	65	65	150	150
HENRIETTA	6	B	55	65	90	130	60	150
HERKIMER	3	B	70	70	75	75	130	130
HERMON	4	A	70	70	50	50	105	105
HERO	4	B	70	70	70	70	130	135
HEUVELTON	2	C	70	70	75	75	115	135
HILTON	2	B	70	70	75	75	135	140
HINCKLEY	5	A	70	70	50	50	95	95
HINESBURG	4	C	75	75	60	60	105	105
HOGANSBURG	4	B	70	70	75	75	135	140
HOGBACK	5	C	75	75	50	50	75	75
HOGBACK-RICKER	5	C	75	75	50	50	75	75
HOLDERTON	3	B	60	65	65	75	105	115
HOLLIS	4	C	60	65	50	60	75	95
HOLLY	2	C/D	55	60	60	75	70	95

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
HOLYOKE	3	C	70	70	70	70	75	75
HOLYOKE-ROCK OUTCR	3	C	70	70	70	70	75	75
HOMER	2	B	60	65	65	75	105	125
HONEOYE	2	B	75	75	75	75	140	140
HOOSIC	4	A	75	75	60	60	105	105
HORNELL	2	D	65	70	70	75	95	105
HORNELLSVILLE	3	D	60	65	65	75	85	95
HOUGHTONVILLE	5	C	75	75	65	65	105	105
HOUGHTONVILLE -RAWSON	5	C	75	75	65	65	105	105
HOUSATONIC	3		55	65	70	75	80	115
HOUSEVILLE	2	C	60	65	65	75	105	125
HOWARD	3	A	75	75	70	70	135	135
HUDSON	2	C	70	70	80	80	135	135
HULBERTON	2	C	60	65	70	80	105	125
ILION	2	D	60	65	70	80	90	105
INSULA	4	B	75	75	60	65	90	90
IPSWICH	6	D	50	65	90	99	60	130
IRA	4	C	70	70	65	65	115	120
ISCHUA	3	B	70	70	75	75	100	105
IVORY	2	C	60	65	65	75	90	100
JEBAVY	5	A	55	60	60	70	75	95
JOLIET	4	D	55	65	65	75	60	100
JUNIUS	5	C	55	65	50	60	80	100
KALURAH	4	B	70	70	75	75	135	140
KANONA	2	D	55	65	60	70	77	95
KARS	4	A	70	70	65	65	125	125
KEARSARGE	3	B	70	70	70	70	90	90
KENDAIA	2	C	60	65	65	75	105	125
KIBBIE	3	B	60	65	65	75	110	125
KINGSBURY	1	D	60	65	65	75	95	110
KINZUA	3	B	75	75	75	75	130	130
KNICKERBOCKER	5	A	70	70	65	65	105	105
LACKAWANNA	3	C	75	75	75	75	125	125
LAGROSS	3	A	75	75	75	75	115	115
LAGROSS-HAIGHTS	3	A	75	75	75	75	115	115
LAIRDSVILLE	2	D	70	70	75	75	120	120
LAKEMONT	1	D	55	60	65	75	80	105
LAKEWOOD	5	A	70	70	40	40	75	75
LAMSON	4	B/D	55	65	65	75	75	110

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
LANESBORO	3	C	70	70	75	75	75	75
LANGFORD	3	C	70	70	75	75	120	120
LANSING	2	B	75	75	75	75	140	140
LECK KILL	3	B	75	75	75	75	115	115
LEICESTER	4	C	55	65	65	75	75	105
LEON	5	C	60	65	60	70	70	95
LEWBATH	3	C	75	75	75	75	95	95
LEWBEACH	3	C	75	75	75	75	125	125
LEYDEN	2	C	70	70	75	75	120	125
LIMA	2	B	70	70	75	75	135	140
LIMERICK	3	C	55	65	70	75	80	115
LINDEN	4	B	75	75	75	75	135	135
LINLITHGO	3	B	65	65	70	75	105	115
LIVINGSTON	1	D	50	55	65	75	65	85
LOBDELL	3	B	65	70	75	75	135	135
LOCKPORT	2	D	60	65	70	80	95	120
LORDSTOWN	3	C	75	75	70	70	105	105
LOVEWELL	2	B	70	70	75	75	130	140
LOWVILLE	4	B	75	75	75	75	135	135
LOXLEY	6	A	50	65	90	130	60	130
LUCAS	2	C	70	70	80	80	135	135
LUDLOW	4	C	70	70	75	75	115	120
LUPTON	6	A	55	65	90	140	60	150
LYMAN	4	C	70	70	60	60	75	75
LYMAN-BECKET-BERKSHI	4	C	70	70	60	60	75	75
LYME	5	C	55	65	60	70	75	100
LYONS	2	D	55	60	65	75	80	105
MACHIAS	4	B	70	70	70	70	115	115
MACOMBER	4	C	75	75	75	75	85	85
MACOMBER-TACONIC	4	C	75	75	75	75	85	85
MADALIN	1	D	55	60	65	75	75	105
MADAWASKA	5	B	70	70	60	60	115	115
MADRID	4	B	75	75	65	65	135	135
MALONE	4	C	60	65	65	75	105	125
MANAHAWKIN	6	D	55	65	90	130	60	130
MANDY	3	C	75	75	75	75	105	105
MANHEIM	2	C	60	65	65	75	105	125
MANHONING	2	D	60	65	65	75	90	115
MANLIUS	3	C	70	70	70	70	105	105
MANSFIELD	3	D	50	60	65	75	65	90

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
MAPLECREST	2	B	75	75	75	75	130	130
MARCY	3	D	55	60	65	75	90	95
MARDIN	3	C	70	70	75	75	115	120
MARILLA	3	C	70	70	75	75	120	120
MARKEY	6	A/D	55	65	90	130	60	150
MARLOW	4	C	75	75	60	60	120	120
MARTISCO	6	B	50	65	90	120	60	120
MASSENA	4	C	60	65	65	75	105	125
MATOON	1	D	60	60	65	75	100	120
MATUNUCK	6	D	50	65	90	130	60	130
MEDIHEMISTS	6	A/D	55	65	90	130	60	150
MEDOMAK	3	D	50	55	65	75	60	80
MELROSE	4	C	75	75	50	50	120	120
MENLO	4	D	55	60	60	70	80	95
MENTOR	4	B	75	75	60	60	125	125
MERRIMAC	4	A	70	70	75	75	105	105
MIDDLEBROOK	3	C	70	70	75	75	105	110
MIDDLEBROOK-MONGAUP	3	C	70	70	75	75	105	110
MIDDLEBURY	3	B	65	70	75	75	135	135
MILLIS	4	C	75	75	60	60	120	120
MILLSITE	4	C	70	70	65	65	100	100
MINEOLA	4	A	70	70	75	75	125	130
MINER	1	D	55	60	65	75	75	105
MINO	4	C	60	65	50	60	100	125
MINOA	4	C	60	65	50	60	100	125
MOHAWK	2	B	70	70	75	75	140	140
MOIRA	4	C	70	70	70	70	100	110
MONADNOCK	4	B	75	75	60	60	95	95
MONARDA	4	D	60	65	65	70	95	115
MONGAUP	3	C	75	75	70	70	105	105
MONTAUK	4	C	70	70	65	65	135	135
MOOERS	5	B	70	70	60	60	95	100
MOROCCO	4	C	55	65	60	65	90	115
MORRIS	3	C	60	65	65	75	95	105
MOSHERVILLE	4	C	60	65	60	70	100	125
MUCK	6	D	55	65	90	130	60	150
MUCK-PEAT	6	D	55	65	90	130	60	150
MUNDAL	4	C	75	75	60	60	65	65
MUNDALITE	3	C	75	75	70	70	105	105

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
MUNDALITE-RAWSONVILL	3	C	75	75	70	70	105	105
MUNSON	2	D	60	65	65	75	105	120
MUNUSCONG	4	B	55	65	60	65	60	95
MUSKEGO	6	A/C	55	65	90	130	60	150
MUSKELLUNGE	3	D	60	65	65	75	90	115
NAPOLEON	6	A	55	65	90	130	60	150
NAPOLI	3	C	60	65	65	75	80	90
NASSAU	4	C	70	70	50	50	85	85
NAUMBURG	5	C	55	65	60	65	90	100
NEHASNE	4	B	75	75	70	70	130	130
NELLIS	4	B	75	75	70	70	140	140
NEVERSINK	4	D	55	60	60	70	75	90
NEWFANE	4	B	75	75	50	50	125	125
NEWSTEAD	4	C	55	65	60	70	95	115
NEWTON	5	A/D	50	60	50	60	80	90
NIAGARA	3	C	60	65	65	75	110	125
NICHOLVILLE	4	C	70	70	70	70	105	110
NINIGRET	4	B	70	70	70	70	130	135
NORCHIP	3	D	55	60	70	80	60	80
NORWELL	5	C	60	65	60	70	100	120
NORWICH	3	D	55	60	60	70	70	90
NUNDA	2	C	70	70	75	75	125	130
OAKVILLE	5	A	70	70	50	50	90	100
OCCUM	4	B	75	75	75	75	140	140
ODESSA	2	D	60	65	75	75	105	115
OGDENSBURG	4	C	55	65	60	70	95	115
OLEAN	2	B	70	70	75	80	125	130
ONDAWA	4	B	75	75	75	75	135	135
ONEIDA	4	C	60	65	65	75	105	125
ONOVILLE	3	C	70	70	70	75	105	115
ONTARIO	2	B	75	75	75	75	140	140
ONTEORA	3	C	60	65	65	75	90	115
ONTUSIA	3	C	60	65	60	70	95	105
OQUAGA	3	C	70	70	65	65	100	100
ORAMEL	2	C	70	70	75	75	130	130
ORGANIC	6	A/D	50	65	90	130	60	130
ORPARK	2	C	60	65	65	75	100	110
ORWELL	2	D	55	60	65	75	90	100
OSSIPEE	6	D	55	65	90	130	60	150
OTEGO	2	B	70	70	70	75	140	150
OTISVILLE	4	A	70	70	50	50	95	95

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
OTSEGO	3		70	70	75	75	115	120
OTTAWA	5	A	70	70	50	50	115	115
OVID	2	C	65	70	70	75	105	125
PALATINE	2	B	65	70	65	70	100	100
PALMS	6	A/D	50	65	90	140	60	150
PALMYRA	3	B	75	75	70	70	140	140
PANTON	1	D	55	65	65	75	90	105
PAPAKATING	2	D	55	60	60	75	70	95
PARISHVILLE	4	C	70	70	70	70	100	110
PARSIPPANY	1	D	50	60	60	75	80	105
PATCHIN	3	D	55	60	65	75	65	85
PAWCATUCK	6	D	50	65	90	130	60	130
PAWLING	4	B	70	70	75	75	140	140
PAXTON	4	C	75	75	65	65	125	125
PEACHAM	3	D	55	60	70	80	60	75
PEAT	6	A/D	55	65	90	130	60	150
PEAT-MUCK	6	A/D	55	65	90	130	60	150
PERU	4	C	70	70	60	60	115	120
PETOSKEY	4	A	75	75	50	50	125	125
PHELPS	3	B	70	70	70	70	140	140
PHILO	3	B	70	70	75	75	135	135
PILLSBURY	4	C	60	65	65	75	70	100
PINCKNEY	3	C	70	70	75	75	115	120
PIPESTONE	5	B	60	65	55	65	70	100
PITTSFIELD	4	B	75	75	75	75	140	140
PITTSTOWN	4	C	65	70	70	70	125	135
PLAINBO	5	A	70	70	50	50	80	80
PLAINFIELD	5	A	70	70	30	30	90	90
PLESSIS	3	D	60	65	65	75	80	95
PLYMOUTH	4	A	70	70	50	50	75	75
PODUNK	4	B	70	70	75	75	130	130
POLAND	2	B	75	75	75	75	140	140
POMPTON	4	B	70	70	50	50	115	115
POOTATUCK	4	B	70	70	65	65	130	130
POPE	4	B	75	75	75	75	140	140
POTSDAM	4	C	70	70	70	70	120	120
POYGAN	1	D	50	60	60	70	70	90
PUNSIT	3	C	60	65	65	75	95	110
PYRITIES	4	B	75	75	75	75	140	140
QUETICO	4	D	70	70	50	50	65	65
QUETICO-ROCK OUTCRO	4	D	70	70	50	50	65	65

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
RAQUETTE	4	B	60	70	60	70	105	120
RAWSONVILLE	5	C	75	75	50	50	75	75
RAWSONVILLE-BESEMAN-	5	C	75	75	50	50	75	75
RAYNE	3	B	75	75	75	75	130	130
RAYNHAM	3	C	55	65	65	75	95	125
RAYPOL	3	C	55	60	60	75	75	90
RED HOOK	4	C	60	65	65	75	105	125
REDWATER	3	B	65	70	75	75	135	135
REMSEN	2	D	60	65	65	75	90	115
RETSOF	2	C	60	65	65	75	95	115
REXFORD	4	C	50	65	65	75	90	110
RHINEBECK	2	D	60	65	65	75	105	120
RICKER	4	A	70	70	60	60	75	75
RICKER-LYMAN	4	A	70	70	60	60	75	75
RIDGEBURY	4	C	55	65	60	70	90	110
RIFLE	6	A	50	65	90	130	60	130
RIGA	2	D	70	70	75	75	120	120
RIPPOWAM	4	C	55	65	60	70	80	105
RIVERHEAD	4	B	75	75	40	40	105	105
ROCKAWAY	2	C	75	75	75	75	125	125
ROMULUS	2	D	55	60	60	75	80	100
ROSS	2	B	75	75	75	75	155	155
ROUNDABOUT	3	C	60	60	60	70	95	110
RUMNEY	2	C	55	65	65	75	85	115
RUNEBERG	4	C	50	55	60	70	70	90
RUSE	4	D	55	60	55	65	75	90
RUSHFORD	3	B	70	70	75	75	120	125
SACO	3	D	50	55	65	75	65	95
SALAMANCA	3	B	70	70	75	75	100	105
SALMON	4	B	75	75	70	70	115	115
SAPRISTS	6	A/D	55	65	90	130	60	150
SAUGATUCK	5	C	60	65	60	70	70	95
SCANTIC	2	D	55	60	65	75	90	100
SCARBORO	4	D	55	65	60	70	75	105
SCHOHARIE	1	C	70	70	75	75	135	135
SCHROON	5	B	70	70	50	50	130	130
SCHUYLER	3	B	70	70	75	75	115	115
SCIO	3	B	70	70	75	75	135	140
SCITUATE	4	B	70	70	75	75	115	115
SCRIBA	4	C	60	65	65	75	94	105
SEARSPORT	4	D	55	65	60	70	75	105

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
SHAKER	2	C	60	65	65	75	105	125
SHOREHAM	2	D	50	60	70	70	65	95
SISK	4	C	55	60	65	75	60	85
SKERRY	5	C	60	65	65	75	95	100
SLOAN	3	B	50	55	65	75	70	90
SODUS	4	C	75	75	75	75	120	120
SOMERSET	5	C	60	65	65	75	90	105
ST JOHNS	4	D	55	65	60	70	75	105
STAATSBURG	3	C	75	75	70	70	90	90
STAFFORD	4	C	60	65	50	60	95	110
STEAMBURG	3	B	70	70	75	75	100	105
STETSON	5	B	75	75	70	70	110	110
STISSING	4	C	60	65	60	70	90	115
STOCKBRIDGE	3	C	75	75	75	75	140	140
STOCKHOLM	5	C	60	60	60	70	90	100
STOWE	4	B	75	75	65	65	110	110
SUDBURY	4	B	60	65	65	65	105	110
SUFFIELD	2	B	70	70	80	80	135	135
SUMMERVILLE	4	D	70	70	50	50	80	80
SUN	4	D	55	60	60	70	75	100
SUNAPEE	4	B	70	70	65	65	95	110
SUNCOOK	5	A	70	70	40	40	90	90
SUNY	4	D	50	55	60	70	70	110
SURPLUS	4	C	55	60	65	75	60	90
SURPLUS-SISK	4	C	55	60	65	75	60	90
SUTTON	4	B	70	70	70	70	130	130
SWANTON	4	C	60	65	50	60	95	125
SWARTSWOOD	4	C	75	75	70	70	120	120
SWORMVILLE	1	C	60	65	65	75	90	115
TACONIC	3	C	75	75	75	75	75	90
TACONIC-MACOMBER	3	C	75	75	75	75	75	90
TAWAS	6	A	50	65	90	130	60	130
TEEL	2	B	65	70	75	75	140	140
TOLEDO	2	D	50	60	70	80	70	100
TONAWANDA	2	D	60	65	65	75	105	120
TOR	4	D	60	60	65	75	60	85
TORULL	3	D	60	65	65	75	90	110
TOWERVILLE	3	B	70	70	75	75	115	115
TRESTLE	3	B	75	75	75	75	145	145
TROUT RIVER	5	A	70	70	50	50	95	95
TROY	3	C	70	70	70	70	120	125

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
TRUMBULL	1	D	55	60	65	75	75	105
TUGHILL	4	D	50	55	55	65	60	85
TULLER	3	D	60	65	65	75	80	95
TUNBRIDGE	4	C	75	75	70	70	90	90
TUNBRIDGE-ADIRONDACK	4	C	75	75	70	70	90	90
TUNKHANNOCK	3	A	75	75	75	75	120	120
TURIN	2	C	60	65	70	80	105	125
TUSCARORA	4	C	70	70	50	50	125	125
UNADILLA	3	B	75	75	75	75	140	140
VALOIS	3	B	75	75	75	75	130	130
VARICK	2	D	55	60	75	75	80	100
VARYSBURG	2	B	70	70	75	75	130	130
VENANGO	3	C	60	65	60	70	100	120
VERGENNES	1	C	70	70	75	75	115	120
VLY	3	C	75	75	75	75	90	90
VOLUSIA	3	C	60	65	60	70	95	105
WADDINGTON	4	A	75	75	60	60	125	125
WAINOLA	5	B	60	65	60	70	85	125
WAKELAND	3	C	60	65	75	75	90	115
WAKEVILLE	3	B	60	65	65	75	95	110
WALLACE	5	B	70	70	40	40	90	100
WALLINGTON	3	C	60	65	65	75	105	115
WALLKILL	3	C	50	60	65	80	65	125
WALPOLE	4	C	65	68	55	60	80	105
WALTON	3	C	75	75	75	75	125	125
WAMPSVILLE	3	B	75	75	75	75	140	140
WAPPINGER	3	B	75	75	75	75	140	140
WAREHAM	5	C	60	65	65	75	90	105
WARNERS	3	C	50	60	70	75	75	90
WASSAIC	4	B	70	70	65	65	120	120
WATCHAUG	4	B	70	70	70	70	120	120
WAUMBECK	4	B	70	70	65	65	95	105
WAYLAND	2	C/D	55	60	60	75	70	95
WEAVER	3	C	70	70	75	75	120	130
WEGATCHIE	3	D	55	65	70	80	90	110
WELLSBORO	3	C	70	70	75	75	115	125
WENONAH	4	C	75	75	65	65	130	130
WESTBURY	4	B	60	65	60	70	80	100
WESTLAND	2	C	50	55	60	75	90	110
WETHERSFIELD	4	C	75	75	75	75	120	120
WHARTON	2	C	70	70	75	75	120	120

Soil Name	SMG	HC	N_Eff UD (%)	N_Eff DR (%)	N_Sup UD (lbs N/a)	N_Sup DR (lbs N/a)	YP UD (bu/a)	YP DR (bu/a)
WHATELY	4	D	50	60	60	70	60	105
WHIPPANY	2	C	60	65	65	75	105	115
WHITELAW	4	B	75	75	65	65	135	135
WHITMAN	4	D	50	60	60	75	76	90
WILBRAHAM	4	C	60	65	60	65	95	110
WILLDIN	3	C	70	70	75	75	115	120
WILLETTE	6	A	50	65	90	130	60	130
WILLIAMSON	4	C	70	70	70	70	115	120
WILLOWEMOC	3	C	70	70	75	75	115	125
WILMINGTON	4	D	55	60	60	70	75	110
WILPOINT	1	D	70	70	80	80	105	110
WINDSOR	5	A	70	70	40	40	90	90
WINOOSKI	4	B	70	70	75	75	135	135
WOLCOTTSBURG	1	D	55	60	65	75	75	105
WONSQUEAK	6	D	55	65	90	130	60	150
WOODBRIDGE	4	C	70	70	75	75	120	125
WOODLAWN	4	B	75	75	75	75	80	80
WOODSTOCK	4	D	70	70	60	60	75	75
WOODSTOCK-ROCK OUTCR	4	D	70	70	60	60	75	75
WOOSTER	3	C	75	75	75	75	125	125
WOOSTERN	3	C	75	75	75	75	130	130
WOOSTERN-BATH-VALOIS	3	C	75	75	75	75	130	130
WORDEN	4	C	60	60	65	75	60	75
WORTH	4	C	75	75	70	70	105	105
WURTSBORO	4	C	70	70	70	70	115	120
WYALUSING	3	D	55	60	65	75	75	95
YALESVILLE	4	C	75	75	60	60	105	105
YORKSHIRE	3	C	70	70	75	75	100	110

Table 2: Soil management groups for New York State.

Soil Management Group	General Description
1	Fine-textured soils developed from clayey lake sediments and medium- to fine-textured soils developed from lake sediments.
2	Medium- to fine-textured soils developed from calcareous glacial till and medium-textured to moderately fine-textured soils developed from slightly calcareous glacial till mixed with shale and medium-textured soils developed in recent alluvium.
3	Moderately course textured soil developed from glacial outwash and recent alluvium and medium-textured acid soil developed on glacial till.
4	Course- to medium-textured soils formed from glacial till or glacial outwash.
5	Course- to very course-textured soils formed from gravelly or sandy glacial outwash or glacial lake beach ridges or deltas.
6	Organic or muck lands.

Table 3: County precipitation and runoff.

County	Precipitation	
	Annual[1] (PA)	October through March[2] (PW)
Albany	41.9	19.2
Allegany	37.8	16.7
Bronx	41.9	19.2
Broome	41.5	19.0
Cattaraugus	37.8	16.7
Cayuga	34.5	15.0
Chautauqua	37.6	17.8
Chemung	37.8	16.7
Chenango	41.5	19.0
Clinton	33.6	14.8
Columbia	41.9	19.2
Cortland	41.5	19.0
Delaware	41.5	19.0
Dutchess	41.9	19.2
Erie	37.6	17.8
Essex	33.6	14.8
Franklin	36.0	16.0
Fulton	44.3	20.5
Genesee	37.6	17.8
Greene	41.5	19.0
Hamilton	43.4	20.4
Herkimer	44.3	20.5
Jefferson	37.6	17.8
Kings	46.0	23.0
Lewis	43.4	20.4
Livingston	34.5	15.0
Madison	41.5	19.0
Monroe	37.6	17.8
Montgomery	44.3	20.5
Nassau	46.0	23.0
New York	46.0	23.0
Niagara	37.6	17.8
Oneida	44.3	20.5

[1] USDA SCS. 1992. Agricultural Waste Management Field Handbook. Part 651 Figures 10C-1, 10C-2.
[2] C. Liezert. Agricultural Waste Management Software 2.21. 1995. Ohio Engineering USDA NRCS.

Table 3 (continued): County precipitation and runoff.

County	Precipitation	
	Annual[1]	October through March[2]
	(PA)	(PW)
Onondaga	34.5	15.0
Ontario	34.5	15.0
Orange	41.9	19.2
Orleans	37.6	17.8
Oswego	37.6	17.8
Otsego	41.5	19.0
Putnam	41.9	19.2
Queens	46.0	23.0
Rensselaer	41.9	19.2
Richmond	46.0	23.0
Rockland	41.9	19.2
St Lawrence	36.0	16.0
Saratoga	41.9	19.2
Schenectady	41.9	19.2
Schoharie	41.5	19.0
Schuyler	34.5	15.0
Seneca	34.5	15.0
Steuben	37.8	16.7
Suffolk	46.0	23.0
Sullivan	41.5	19.0
Tioga	41.5	19.0
Tompkins	34.5	15.0
Ulster	41.5	19.0
Warren	33.6	14.8
Washington	41.9	19.2
Wayne	37.6	17.8
Westchester	41.9	19.2
Wyoming	34.5	15.0
Yates	34.5	15.0

[1] USDA SCS. 1992. Agricultural Waste Management Field Handbook. Part 651 Figures 10C-1, 10C-2.
[2] C. Liezert. Agricultural Waste Management Software 2.21. 1995. Ohio Engineering, USDA NRCS.

Picture by Q.M. Ketterings

Q.M. Ketterings, S.D. Klausner, and K.J. Czymmek (2001). Nitrogen Recommendations for Field Crops in New York. Department of Crop and Soil Sciences Extension Series EO1-04. September 2001. 45 pages.