Selecting Synthetic Fertilizers in New Mexico

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What's in this Guide

All soils should be tested for available plant nutrients before adding fertilizer. Be sure to follow NMSU Extension Guide A-109, *Test Determine Soil Needs*, when sampling to assure an accurate representation of your soil conditions. If fertilizer is required, then follow this guide to determine what might be best for your conditions (table 1).

A fertilizer is any organic or inorganic material (or combination) that is added to the soil to supply sufficient amounts of one or more elements essential to the growth of plants. A profitable harvest will depend upon choosing how, when, where, and what kind of fertilizer to apply. Recent scrutiny over the effects of synthetic fertilizers on the environment, poor fertilizer efficiency, high fertilizer prices, and low crop prices have prompted the need for a rational approach to choosing fertilizers in New Mexico. Additionally, a rational approach to fertilization includes knowing plant needs, type of tillage, availability of equipment, short- and long-term effects on the soil, and labor.

Plants require a minimum of 16 nutrients. Plants use nitrogen (N), phosphorus (P), and potassium (K) in significant amounts, so they must be replaced periodically to sustain productivity. Synthetic fertilizers have been developed to supply the three most-used nutrients. Additionally, several fertilizers have been developed to supply the other 13 nutrients when needed.

All materials sold as fertilizer in New Mexico must specify the *grade*, or guaranteed analysis, of the material. Grades are stated in terms of the minimum percentage of nitrogen (N), available phosphorus as phosphoric acid (P_2O_5), and water-soluble potash (K_2O), in that order (table 1). Thus, a bag of fertilizer that has the numbers 10-10-10 contains 10% nitrogen, 10% phosphorus as P_2O_5, and 10% potassium as K_2O. In other words, a 50-pound bag of fertilizer with the numbers 10-10-10 contains 5 pounds of N, 5 pounds of P_2O_5, and 5 pounds of K_2O.

Fertilizer Types

Current information on synthetic fertilizers is presented in table 1.

A *complete fertilizer* is a chemical compound (or blend) containing significant quantities of the three primary fertilizer nutrients (N, P, and K).

Bulk-blended fertilizer is a physical mixture of dry, granular fertilizer≠ materials to produce specific fertilizer grades. Individual granules in the bulk-blended fertilizer do not have the same ratio and content of plant food as does the mixture as a whole.

Mixed fertilizer is composed of two or more fertilizer materials blended or granulated together into individual mixes. The term includes powders, granules, flakes, liquids, suspensions, and slurry mixtures. Specific blends should be based on soil test results and crop needs (see Guide A-109, *Test Determine Soil Needs*).

Forms

In addition to the different types of synthetic fertilizers, there are several physical forms by which they are marketed. The physical forms include gas, dry solid, liquid, slurry, and suspension.

Gas. Anhydrous ammonia (NH_3) is the only gas fertilizer marketed in the United States, however, it is stored and distributed as a compressed liquid. Liquid ammonia expands instantly to a gas when it moves

Table 1. Types and characteristics of synthetic nitrogen fertilizers.

Fertilizer	Chemical formula	% N, P, K	Form	Application method	Advantages	Disadvantages
Ammonium nitrate	NH_4NO_3	34% N	Dry pellets	Broadcast or sidedressed.	NO_3 is immediately available. Among dry fertilizers, second only to urea in percentage N.	NO_3 (1/2 of the N it contains) is leachable, and also subject to denitrification in warm, wet soil. Hardens upon exposure to air.
Ammonium phosphate	$NH_4H_2PO_4$	11% N 21% P	Dry granules	Broadcast or drilled.	Phosphorus is completely water soluble. Desirable N to P ratio for row fertilizer, especially where K is not needed.	High residual acidity.
Ammonium phosphate and ammonium sulfate	$NH_4H_2PO_4$ $(NH_4)_2SO_4$	16% N 9% P	Dry granules	Broadcast or drilled.	See ammonium phosphate and ammonium sulfate.	
Ammonium polyphosphate	$(NH_4)(H_3P_2O_7)$	10% N 15% P	Liquid	Broadcast or drilled.	Completely water soluble source of P.	Cannot come in contact with seed.
Ammonium polyphosphate	$(NH_4)(H_3P_2O_7)$	15% N 27% P	Dry	Broadcast or drilled.	Completely water soluble source of P.	Cannot come in contact with seed.
Ammonium sulfate	$(NH_4)_2SO_4$	21% N	Dry granules or pellets	Broadcast or sidedressed.	Acidifying effect desirable on alkaline soils.	Low analysis. Medium price. Highest acidifying effect of N sources.
Anhydrous ammonia	NH_3	82% N	Compressed gas, 204 lb per square inch at 104°F	Injecting 6" or deeper in moist but not saturated soil.	Low price. Non-leachable.	Requires high-pressure storage and applicators.
Aqua ammonia	NH_4OH in water	21% N	Liquid	Inject at least 1 inch (2.5 cm) or deeper below soil surface.	Low price.	Must be covered to avoid ammonia escaping.
Calcium cyanamide	$CaCN_2$	21% N	Black, dry pellets	Broadcast or sidedressed.	Can be used as an herbicide and as a defoliant (powdered form).	High price, intermediate reaction products are toxic.
Calcium nitrate	$Ca(NO_3)_2$	16% N	Dry granules	Broadcast or sidedressed.	Same as sodium nitrate.	
Diammonium phosphate	$(NH_4)_2HPO_4$	18 to 21% N 20 to 23% P	Dry granules	Broadcast or drilled.	Low price, completely water soluble source of P.	Cannot come in contact with seed.
Nitrogen solutions (Two are listed.)	Urea in ammonium nitrate solution	30% N	Liquid	Sprayed or sidedressed.	No pressure equipment needed.	Some risk of loss of urea portion if not incorporated into the soil by tillage or precipitation.
	NH_3 in ammonium nitrate solution	41% N	Liquid	Injected 1 to 2 deep preplant or sidedressed.	Non-leachable until changed to NO_3.	Slight vapor pressure of NH_3. Must be covered 1 to 2 inches to prevent loss. Cannot come in contact with seed.
Potassium nitrate	KNO_3	14% N 38% K	Dry granules	Broadcast or sidedressed.		
Sodium nitrate	$NaNO_3$	16% N	Dry granules	Broadcast or sidedressed.	Immediately available and non-acid forming.	Very high price, and sodium can raise pH.
Urea	$CO(NH_2)_2$	46% N	Dry pellets	Broadcast, sidedress, add to solutions, and liquid spray on some crops.	High solubility. Non-leachable after it is converted to NH_4.	Leachable by rain shortly after application. Some risk of loss of NH_3 to atmosphere if not incorporated into the soil by tillage or precipitation.
Ureaform	$CO(NH_2)_2$ combined with formaldehyde	38% N	Dry granules	Broadcast or sidedressed	Nitrogen is released over several weeks rather than all being available immediately.	High price for field crops. Variable rate of N release. Depends somewhat on moisture and temperature.

Adapted from Aldrich, et. al., 1986.

out of the application knives. Ammonia gas reacts with water to form the ammonium ion (NH_4^+) in the soil environment. Anhydrous ammonia is most popular in eastern New Mexico.

Dry solids. Dry solids are best used as a broadcast fertilizer prior to planting. Three different kinds of dry solid fertilizers are available in New Mexico: completely water soluble, dry mixes, and dry blends.

- *Completely water-soluble dry pellets* are fertilizer nutrients that have been chemically combined with water to form a solution and then evaporated, leaving a uniform, dry solid.

- *Dry mix* (bulk mix) are mixtures of pellets in which each pellet has only one nutrient.

- *Dry blends* are mixtures of pellets that have more than one nutrient associated with them.

Liquid. A liquid fertilizer is a fluid in which the plant nutrients are in true solution (wholly dissolved). Other liquid fertilizers that can be handled as liquids include suspensions and slurries. Because liquids can be applied through a planter and combined with herbicides, they have become quite popular. Liquids are best suited to applications where the material can be injected through knives attached to tillage implements or injected into irrigation water (see California Fertilizer Association's *Western Fertilizer Handbook*).

- *Slurries* are combinations of liquid and dry forms. The solid particles are prevented from settling by constant stirring within the tank.

- *Suspensions* are fluid fertilizers containing dissolved and undissolved plant nutrients. The undissolved plant nutrients are kept in suspension with a suspending agent. The suspension must be flowable enough to be mixed, pumped, agitated, and applied to the soil in a homogeneous mixture. Agitation is not always required.

Incorporating Fertilizers

Most fertilizers should be incorporated either with tillage or irrigation water. Incorporation reduces nitrogen losses due to *volatilization* (loss as a gas) and places the nutrients in the crop root zone.

Conventional tillage systems that mix the top of the soil profile will incorporate surface-applied fertilizer. No-till and minimum-till operations will not incorporate fertilizer into the crop root zone. Tillage systems affect fertilizer management decisions because some nutrients (such as phosphorus and potassium) do not readily move through the soil to the crop root zone where the nutrient can be taken up by the plant.

Nitrogen management can also be affected by the tillage system. For example, use of anhydrous ammonia requires that the slit left by the injection knife be completely closed to prevent loss of gaseous nitrogen. Reduced-till and no-till systems also require that the slit left by an ammonia application be completely closed. Also, urea-containing fertilizers should be incorporated to reduce loss of gaseous nitrogen.

Drip irrigation systems are also ideal systems for placing fertilizer close to the root system. Depending on the depth of the drip tape, fertilizer may also be broadcast and incorporated.

Application Methods

The best method of fertilizer application depends on the crop, available equipment, fertilizer-pesticide combination, labor, irrigation and tillage practices, and type of fertilizer. A major goal of many producers is to improve fertilizer efficiency (that is, greater crop yield per unit of fertilizer applied). The choice of method, however, also must meet future agronomic and environmental requirements.

Broadcasting is the surface application of fertilizer to the soil either before or after the crop has been established. The broadcast application may or may not be incorporated.

Deep placement is also referred to as dual placement, knife injection, and root-zone banding. Generally, with this method a mixture of nitrogen and phosphorous (sometimes N-P-K) is injected into the soil at a depth of 4–8 inches. The knife spacing is usually 15–30 inches (spacing depends on row spacing).

Dribble is the surface application of fertilizer to the soil, but differs from broadcast because it is applied in bands (for example, 30-inch spacings). Often this method is used when the producer is using a urea-ammonium nitrate solution fertilizer.

Foliar application is the placement of a dilute fertilizer solution on the leaves of the crop. Foliar applications are used when small amounts are needed and can be absorbed through the leaves.

Pop-up or *starter* refers to fertilizer placed in small amounts in direct contact with the seed. Starter fertilizers generally have a grade of 1-4-2 and are applied at 10–15 lb/acre.

Pre-plant fertilizers are applied during tillage preparation and often are incorporated into the soil. Some herbicides can be mixed with pre-plant fertilizers.

Post-emergent applications occur after the crop has emerged from the soil. This is an efficient method for applying nitrogen fertilizers because the nitrogen is applied just prior to the period of greatest demand.

Drip, center pivot, and linear move irrigation systems may be the most efficient ways to apply post-emergent fertilizer.

Row refers to the placement of fertilizer in a concentrated band below and to the side of the seed. In addition, this method includes side-dressing, which is the application of fertilizer to the side of young roots after crop emergence.

Strip placement generally refers to the application of phosphorus and potassium fertilizers in narrow bands on the soil surface. Often this method is used with mold board plowing practices in order to distribute a band of fertilizer throughout the plow layer.

Variable rate (site-specific) applications refer to the use of precision farming technology (using personal computers and technologies such as geographic information software and global positioning satellites) to alter the rate of fertilizer application as the equipment travels across the field.

Changing Soil pH

It is occasionally necessary to increase soil acidity. Acidification properties of fertilizers should be considered in fertilizer choice because of the high pH conditions of New Mexico soils. The elements used to reduce soil pH are elemental sulfur, sulfuric acid, aluminum sulfate, iron sulfate, and ammonium polysulfide. Ammonium sulfate, ammonium phosphate, and similar compounds have been considered effective in short-term decreases in pH, but have no real long-term effects on pH. Short-term and localized reductions in pH are more common for sodium-affected soils where sulfur replaces the sodium (table 2).

Salt index. Injury can result from synthetic nitrogen, phosphorous, and potassium fertilizers applied at high rates, which increase the salt concentration in the soil solution near the seed or the young root system. A salt-index was developed to compare the "saltiness" of the synthetic fertilizers. The index is the ratio (× 100) of the decrease in osmotic potential of a solution containing a fertilizer to that produced by the same weight of $CaNO_3$. In other words, a salt index (table 2) indicates the probability of fertilizer burn from fertilizer application. Therefore, fertilizers with a low salt index are generally considered to have a lower risk of injury when applied properly. However, although higher grade fertilizers have a high salt index, it takes less of a high grade fertilizer to supply the same amount of nutrient as a low grade fertilizer. Therefore, on a per-nutrient basis, the salt index is generally lower for high grade fertilizers (table 3).

Table 2. Short- and long-term effects of synthetic fertilizer on soil pH.

	Effect on soil pH	
Fertilizer	Immediate	Long-term
Nitrogen sources		
Anhydrous ammonia	strongly basic	moderately acidic
Ammonium nitrate	none	moderately acidic
Ammonium sulfate	none	strongly acidic
Calcium nitrate	none	basic
Urea	slightly basic	moderately acidic
Phosphorus and nitrogen sources		
Monoammonium phosphate	none	strongly acidic
Diammonium phosphate	none	acidic
Superphosphate, 20% P_2O_5	none	moderately acidic
Superphosphate, 48% P_2O_5	none	moderately acidic
Potassium sources		
Potassium nitrate	very little	basic
Potassium sulfate	none	neutral

Table 3. Salt index of selected synthetic fertilizers.

Fertilizer	Salt index
Table salt (NaCl)	153
Reference ($CaNO_3$)	100
Nitrogen sources	
Anhydrous ammonia	47.1
Ammonium nitrate	49.3
Ammonium sulfate	69.0
Urea	75.4
Phosphorus and nitrogen sources	
Monoammonium phosphate	34.2
Diammonium phosphate	29.9
Superphosphate, 20% P_2O_5	7.8
Superphosphate, 48% P_2O_5	10.1
Potassium sources	
Potassium nitrate	73.6
Potassium sulfate	46.1

Glossary

acid-forming fertilizer - Fertilizer that increases residual acidity and decreases soil pH.

analysis fertilizer - The percent composition of a fertilizer as determined in a laboratory and expressed as total nitrogen (N), available phosphoric acid (P_2O_5), and water-soluble potash (K_2O).

blended fertilizer - A mechanical mixture of different fertilizer materials.

bulk-blended fertilizer - A physical mixture of dry granular fertilizer materials to produce specific fertilizer ratios and grades. Individual granules in the bulk-blended fertilizer do not have the same ratio and content of plant food as does the mixture as a whole.

complete fertilizer - A chemical compound or a blend of compounds containing significant quantities of nitrogen, phosphorous, and potassium. It may contain other plant nutrients.

compound fertilizer - A fertilizer formulated with two or more plant nutrients.

controlled-release fertilizer - Also called *delayed released*, *slow release*, *controlled availability*, *slow acting*, and *metered release.* A controlled dissolution of fertilizer at a lower rate than conventional water-soluble fertilizers. Controlled-release properties may result from coatings on water-soluble fertilizer or from low dissolution and/or mineralization rates of fertilizer materials in soil.

fertilizer - Any organic or inorganic material of natural or synthetic origin (other than liming material) that is added to a soil to supply one or more elements essential to the growth of plants.

fertilizer grade - The guaranteed minimum analysis in percent of the major plant nutrient elements contained in a fertilizer material or in a mixed fertilizer. The analysis is usually designated as N-P_2O_5 - K_2O, but it may be N-P-K where permitted or required as specified by state law. Grades must be expressed in percent N-P-K for Soil Science Society of America publications (oxide values may be included in parentheses).

fertilizer ratio- The relative proportions of primary nutrients in a fertilizer grade divided by the highest common denominator for that grade. For example, grades 10-6-4 and 20-12-8 have a ratio of 5-3-2.

fertilizer requirement - The quantity of certain plant nutrients needed, in addition to the amount supplied by the soil, to increase plant growth to a designated level.

fertilizer salt-index - The ratio of the decrease in osmotic potential of a solution containing a fertilizer compound or mixture to that produced by the same weight of $NaNO_3$ × 100.

fluid fertilizer - Fertilizer wholly or partially in solution that can be handled as a liquid, including clear liquids and liquids containing solids in suspension.

foliar fertilization - Application of a dilute solution of fertilizer nutrients to plant foliage; usually applied to supplement nutrients absorbed by plant roots.

granular fertilizer - Fertilizer in the form of particles sized between an upper and lower limit or between two screen sizes, usually within the range of 1 to 4 mm and often more closely sized. The desired size may be obtained by agglomerating smaller particles, crushing and screening larger particles, controlling size in crystallization processes, or prilling.

injected fertilizer - Placement of fluid anhydrous ammonia fertlizer into the soil using pressure or nonpressure systems.

inorganic fertilizer - A fertilizer material in which carbon is not an essential component of its basic chemical structure. Urea is often considered an inorganic fertilizer because of its rapid hydrolysis to form ammonium ions in soil.

mixed fertilizer - Two or more fertilizer materials blended or granulated together into individual mixes. The term includes dry mix powders as well as granulated, clear liquid, suspension, and slurry mixtures.

organic fertilizer - A material containing carbon and one or more plant nutrients in addition to hydrogen and/or oxygen. Urea is often considered an inorganic fertilizer because of its rapid hydrolysis to form ammonium ions in soil.

pop-up fertilizer - Fertilizer placed in small amounts in direct contact with the seed.

side-dressed fertilizer - Application made to the side of crop rows after plant emergence.

slow-release fertilizer - A fertilizer applied in relatively small amounts with or near the seed; the nutrient is not immediately available for the crops, but is released slowly over time.

soil fertility - The ability of a soil to supply the nutrients essential to plant growth.

suspension fertilizer - A fluid fertilizer containing dissolved and undissolved plant nutrients. The undissolved plant nutrients are kept in suspension with a suspending agent, usually a swelling type clay. The suspension must be flowable enough to be mixed, pumped, agitated, and applied to the soil in a homogeneous mixture.

top-dressed fertilizer - The surface application of fertilizer to a soil after the crop has been established.

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