COLLEGE *of* FOOD, AGRICULTURAL, *and* ENVIRONMENTAL SCIENCES

Ohio Fertilizer Applicator 2023

Field Crop Fertility Update

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THE OHIO STATE UNIVERSITY EXTENSION

Pesticide Safety Education Program, Ohio State University Extension

N, P & K Decisions with High Fertilizer Prices

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A perfect storm of supply shocks, weather events, plant closures, imperfectly competitive and shallow market structure, and a series of policy changes has been brewing and is now culminating into concerning price volatility and deterioration in fertilizer affordability (Beghin, 2021). Higher fertilizer prices look to be with us through the next year or more. Getting back to basics, a reliable soil test, and a good understanding of university nutrient recommendations will give you the critical information needed to make sound, profitable nutrient decisions with high fertilizer prices. The guide to nutrient decisions is found in the *Tri-state Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa* at https://go.osu.edu/fertilizer. Let's walk through our three major nutrients nitrogen, phosphorus, and potassium.

Nitrogen

There are few substitutes for fertilizer nitrogen application to grow corn and wheat, and it is our highest-cost nutrient. Therefore, when allocating fertilizer dollars, start with nitrogen in the crop budget. Tri-state recommendations for nitrogen in corn and wheat both use a yield to nitrogen response curve but apply two different strategies in using the curve. In corn, we use the yield response curve with the price of corn and nitrogen to find the best economic return along the yield curve. We use the yield response curve with the potential wheat yield in wheat. Soil tests do not generally come into play with N rate management except with manure or higher soil organic matter field location.

Rate recommendations in corn

The response of corn to added nitrogen is not linear, where each added unit of N would result in an added bushel of corn. The reality is as the N rate nears the optimum rate, the increase in yield from each unit of N approaches zero, with any N applied beyond the optimum rate wasted. As a result, universities across the Midwest have moved to a data-driven approach to corn nitrogen recommendations. The approach incorporates a corn yield response curve with nitrogen and corn prices to identify the optimum economic rate of N that provides the maximum return to nitrogen (MRTN). Calculating the MRTN requires four inputs: 1) location, 2) the previous crop grown (corn; soybean or small grain), 3) price of nitrogen fertilizer, and 4) price expected per bushel of corn.

Table 1 shows the price of nitrogen fertilizer at various costs per pound and the equivalent per ton price of two familiar nitrogen sources used in Ohio. Table 2 shows Ohio recommended nitrogen rate for corn following soybean at various price combinations for corn and nitrogen. First, select the nitrogen price, look down the column, select the corn price, and look across the row; the cell where the selections intersect is the recommended nitrogen rate.

Table 1. Price per Ton of Anhydrous and 28% UAN at Various Price per Pound of Nitrogen Fertilizer Costs.

	Price of Nitrogen Fertilizer ($/lb)						
N Source	**$0.45**	**$ 0.55**	**$0.65**	**$0.75**	**$0.85**	**$0.95**	**$1.05**
82-0-0	$738	$900	$1066	$1230	$1394	$1558	$1722
28-0-0	$252	$308	$364	$420	$476	$532	$588

Table 2. Ohio MRTN recommended Nitrogen Rates (lbs nitrogen/acre) for Corn following Soybean based on the Price of Corn Grain and Nitrogen Fertilizer.

	Price of Nitrogen Fertilizer ($/lb)						
Price/Bushel Corn	**$0.45**	**$ 0.55**	**$0.65**	**$0.75**	**$0.85**	**$0.95**	**$1.05**
$4.50	180	169	159	150	143	136	129
$5.00	185	175	165	157	149	142	136
$5.50	190	180	171	162	155	148	142
$6.00	195	185	176	168	160	153	147
$6.50	200	188	180	172	165	158	152
$7.00	200	192	184	176	169	163	157

A dynamic tool where you can use your rotation plus nitrogen and corn price in a calculator with Ohio nitrogen response data is found at http://cnrc.agron.iastate.edu/. The corn N rate recommendations assume best management practices are used. Therefore, the recommended N fertilizer rate represents the total N to be applied over the growing season, regardless of the timing of N application. Application timing and placement practices that result in N loss will often require higher N rate applications to maximize profit. Soybean or crop rotation credits are based on field trials built into the recommendations.

Soil tests are generally not used for nitrogen rate recommendations. The exception is when applications of manure, biosolids, or other nitrogen sources are made to a field. In these situations, a presidedress nitrogen test (PSNT) is helpful to adjust the N rate. Table 3 shows suggested adjustments to N rates based on PSNT.

Table 3. Suggested adjustments to the MRTN rate by soil nitrate test levels in a manure system. Source: (https://www.agry.purdue.edu/ext/pubs/ay-314-w.pdf) and (Camborato, Personnel Com)

Soil NO3-N (ppm)	Adjustment to MRTN rec. N rate (lb N/acre)
0 - 10	Full Rate
11 – 15	-30
16 – 20	-45
21 – 25	-90
>25	No sidedress N

The PSNT was used to adjust N rates in plots at Northwest Research Station, OARDC, in 2021. Results are shown in Table 4. A full MRTN rate of 186 pounds of N per acre was compared to rates reduced by 30 lbs/A when the PSNT was 10-12 PPM and 45 pounds with a 14 PSNT test. The PSNT performed as expected except for the fall dairy manure applied at 8000 gal/A.

In addition to the PSNT test, farmers are encouraged to use other available information such as weather, soil type, management history, and previous performance to help refine a localized N rate for any given field. Emerging technologies such as crop sensors and weather-driven soil-crop models may also guide N management decisions.

Table 4. Corn yield response to full MRTN and PSNT adjust nitrogen rates with fall-applied swine and dairy manure at two rates.

Fall Manure (gal/A)	Manure Type	Sidedress Pounds of N	PSNT Nitrate-N (PPM)	Average Yield (bu/A)
0	None	0	--	65
5000	Swine	141	10	238
5000	Swine	186	--	244
8000	Swine	96	14	238
8000	Swine	186	--	245
8000	Dairy	141	10	224
8000	Dairy	186	--	239
12000	Dairy	141	12	241
12000	Dairy	186	--	242
		LSD (0.05)	2	15
		CV %	11	5

Rate recommendations in wheat

When developing an optimal N fertilizer rate for soft winter wheat, soil texture, organic matter, residual manure or fertilizer contributions, crop rotation, planting date, and yield potential should be considered. Due to lower water-holding capacity and lower organic matter levels, sandier soils may require greater N rates than loamy or clayey soils. Drainage impacts wheat growth as soils can be waterlogged in the spring during critical periods of growth and development, thus reducing yield goals. Due to denitrification, soils with low infiltration rates or inadequate tile drainage may lose a significant portion of applied N. Crop rotation may impact yield potential through C:N ratios of crop residues and soil residual N following the previous crop. Perhaps most importantly, a timely planted winter wheat crop will enable sufficient development and tillering in the autumn, potentially allowing for reduced N rates than those recommended. All field and in-season growth factors mentioned should be used to adjust the nitrogen recommendations in Table 5.

Table 5. Total (Fall + Spring) Nitrogen Recommendations for Soft Red Winter Wheat. Source (Tri-State Fertilizer Recommendations.

Wheat Yield Potential (bushels/acre)				
60	70	80	90	110
lb N/acre				
70	80	90	110	120

Livestock Manure to Meet Crop N Needs

Livestock manure is a good nutrient source for crop production. Liquid manures tend to be the best nitrogen source to meet corn and wheat N needs. Liquid manure contains a significant amount of ammonium N, which is more suitable to meet N needs than solid manures with N that are primarily organic. To take advantage of manure for corn, incorporated spring or in-crop application timings result in available N that can meet a large portion of the crop need. More information on using manure to substitute for fertilizer N can be found at https://agbmps.osu.edu/bmp/crop-application-manure-sourced-nutrient-maximize-crop-uptake

Phosphorus and Potassium

Reliable Soil Test for P and K decisions

What is the best investment when fertilizer prices are high, a recent reliable soil test! So what is a recent reliable soil test? A recent soil test is no more than four years old. A reliable test is where you believe the number for pH, phosphorous, and potassium on the soil test represents that field you farm. It isn't beneficial if you do not trust the soil test number on the report. If you question your soil report numbers, think about changing how you collect samples for soil testing. You want to consider three things: how much area is sampled with each sample, how deep you are sampling, and what lab you are using.

Yield or past soil test results should drive sample area size decisions. A single sample should not represent more than 25 acres. Grid or zone sampling often results in zone sizes of two to twelve acres and target lime or nutrients to areas of greatest need. Sample depth should be consistent. For sample depth, our Tri-State Recommendations use an 8-inch sample core. Mark your probe at your selected depth. Throw out and take another sample core when cores are compacted in the probe. We like to blame the lab for bad samples, but we generally see more variability in the sample collection process than laboratory procedures. If you want more information on soil sample collection procedures, see the factsheet at https://go.osu.edu/soilsample.

Recent reliable soil test values for pH, phosphorus, and potassium will tell you if you need to apply lime or fertilizer this year or if we can wait. Comparing your soil test values to the Tri-State Fertilizer Recommendations will answer critical questions about your fertility needs. Get your copy of the Tri-state Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa at https://go.osu.edu/fertilizer. The publication is available for sale as a printed copy or a free pdf version.

Address pH through Liming first

The first thing to look at on your soil test reports is pH. Soil pH is the critical factor in nutrient availability. If soil pH is less than 6.0, consider liming before applying fertilizer. When soil pH values are acidic, investing in lime will make more soil stored phosphorus and potassium crop available. Correct soil pH will make other parts of your fertility program more efficient. Spend your fertilizer dollars on lime first.

Phosphorus and Potassium

You have been using a build maintenance fertilization strategy if you have been following our Tri-state Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa. The build maintain strategy has the type of pricing situation we are currently experiencing in mind. Comparing your soil test value for phosphorus and potassium to the critical level defines the need for annual fertilizer application. The text from the recommendation bulletin states, "Soil test levels above the critical level are "optimal," unlikely to be responsive to fertilizer application. Soil test levels below the critical level are "deficient," more likely to have a yield response to fertilizer application." Shown in Table 1 are critical soil test values for phosphorus and potassium in corn, soybean, wheat, and alfalfa. In summary, with a build maintenance approach, as long as soil test values are above the critical level, you can defer fertilizer applications when fertilizer prices are high or weather conditions do not favor application.

Table 1. Critical Soil Test Values from Mehlich 3 Soil Test for Phosphorus and Potassium. From Tri-state Fertilizer Recommendations for Corn, Soybean, Wheat, and Alfalfa, 2020.

Crop	Phosphorus Mehlich 3	Potassium Mehlich 3	
		Soils with CEC <5 meq/100g	Soils with CEC >5 meq/100g
Corn & Soybean	20	100	120
Wheat & Alfalfa	30	100	120

If your crop for 2022 is corn or soybeans, here is how it works. First, scan your soil test reports for less than 20 ppm for P soil values. Below 20 ppm is where the likelihood of yield loss increases. Therefore, the recommendation would be to apply a crop removal rate of P. Determine expected yield based on-field productivity. Then multiply the expected yield by the crop removal for P for the crop. Crop removal is 0.35 pounds P2O5 per bushel for corn, and soybean is 0.80 pounds P2O5 per bushel.

Here is an example. A field (or zone) with a soil test P value of 15 ppm Mehlich 3, and corn yield is 195 bushels per acre. Therefore, the nutrient needed is 68 pounds P2O5, which is 195 multiplied by 0.35. The amount of MAP fertilizer required to meet this need is 131 pounds found by taking 68 pounds P2O5 needed dividing by 0.52, which is the P2O5 percentage of MAP, 11-52-0. If you are using DAP, it would be 148 pounds found by taking 68 pounds P2O5 needed dividing by 0.46, which is the P2O5 percentage of DAP,18-46-0.

Where your soil test reports show soil P values above 20 ppm critical level, you can defer fertilizer applications to when fertilizer prices are more favorable. However, keep in mind that if your soil test values are near the critical level, you can only defer for a short time. Soil test P values decline over time, but change is not dramatic from one year to the next due to the soil's ability to buffer available P. Estimated change in soil test P values is only 2-3 ppm per year from crop removal.

Decisions for potassium are similar to phosphorus. The difference is we need to look at both the Cation Exchange Capacity (CEC) number and the soil test potassium value. If CEC is less than 5, use 100 ppm Mehlich as the critical level. If CEC is greater than 5, use the 120 ppm value. The crop removal for corn is 0.20 pounds of K2O per bushel, and for soybean, it is 1.15 pounds of K2O. Now scan your soil test reports for K soil values less than the critical level. Below the critical level is the situation where the likelihood of yield loss increases. Therefore, the recommendation would be to apply a crop removal rate of K. Determine expected yield based on-field productivity. Then multiply the expected yield by the crop removal for P for the crop. Crop removal is 0.35 pounds P2O5 per bushel for corn, and soybean is 0.80 pounds P2O5 per bushel.

Continue with our example of a field (or zone) with a 195 bushel per acre corn yield and a soil test K level of 110 and CEC of 15 meq/100g. The K2O need would be 39 pounds per acre. The potash fertilizer recommendation would be 65 pounds. This is calculated by taking the 39 pounds K2O needed, divided by 0.60, the K2O percentage of potash, 0-0-60.

Where your soil test reports show soil K values above the critical level, you can defer fertilizer applications to when fertilizer prices are more favorable. However, keep in mind that if your soil test values are near the critical level, you can only defer for a short time. Soil test K values decline over time, while K is buffered like P, the soil changes from one year to the next due tend to be greater than with P. Estimated change in soil test K values are 6-10 ppm per year from crop removal for grain crop but are higher with forages.

We provide a spreadsheet that many folks have found helpful to do nutrient and fertilizer calculations. You can see that tool at https://go.osu.edu/ohiofertilitytool.

Livestock Manure to Meet Crop P & K Needs

Livestock manure is a good P & K nutrient source for crop production. When comparing P_2O_5 and K_2O availability in manure to commercial fertilizer, there are two things to know. First, the pounds of available P and K nutrient shown on the manure test is equivalent to commercial fertilizer. Therefore, those manure nutrients are a one-to-one replacement for commercial fertilizer. Second, manure is not a good substitute when starter fertilizer is needed. The key to using manure in the fertility program is to get a manure nutrient test, then use that test to guide the application. Application rates should be determined using both the manure source's N and P content, being sure not to over-apply either nutrient.

References:

Beghin. J. and L. Nogueira.(2021) A Perfect Storm in Fertilizer Markets. ttps://cap.unl.edu/crops/perfect-storm-fertilizer-markets [Accessed Nov 15, 2021]

Nutrient Management Resources:

Choosing a Laboratory for Nutrient and Soil Health Testing https://ohioline.osu.edu/factsheet/anr-0107

Soil Sampling to Develop Nutrient Recommendations https://ohioline.osu.edu/factsheet/AGF-513

Interpreting a Soil Test Report https://ohioline.osu.edu/factsheet/agf-0514

Developing Phosphorus and Potassium Recommendations for Field Crops https://ohioline.osu.edu/factsheet/agf-0515

Interpreting Manure Sample Test Results https://ohioline.osu.edu/factsheet/anr-55

Phosphorus Nutrient Management for Yield and Reduced P Loss at Edge of Field https://ohioline.osu.edu/factsheet/agf-509

Converting between Mehlich-3, Bray P, and Ammonium Acetate Soil Test Values https://ohioline.osu.edu/factsheet/anr-75

Understanding Manure Nutrients and Utilization

Glen Arnold, Ohio State University Extension Field Specialist, Manure Nutrient Management Application

When land applying manure, the goal is to utilize the fertilizer nutrients for crop production, while avoiding harm to the environment. Properly utilized manure can augment or replace purchased commercial fertilizer. Improperly managed manure can impact water surface quality in streams and ditches.

Generally speaking, manure in Ohio can be divided into solid manure and liquid manure. Solid manure is typically from animals where bedding is used such as sheep, horses, cattle, poults, and turkeys. Manure from laying hens would also be considered solid. Liquid manure is usually dairy, swine, and cattle on slatted flooring. Solid manure analysis reports are in pounds of nutrients per ton of manure. Liquid manure analysis reports are in pounds of nutrients per 1,000 gallons of manure.

Knowing the nutrient content of manure is the first step to efficient utilization. Manure nutrient content varies based on a variety of factors such as animal species, animal age, feeding ration, feed additives, storage time, storage length, bedding materials, and isolation from rainfall or other sources of liquid. Nutrient composition of manure can vary widely from farm to farm but is typically consistent from a single storage facility from year to year unless something major has caused a change.

Table 1 shows typical manure nutrient values from various species. These are only guidelines. There is no substitute for collecting a manure sample at application time and getting a manure analysis.

Table 1.

Species	Total N	NH-4 N	Organic N	P2O5	K2O	Units
Finishing hogs	39.4	32.6	4.6	18.1	26.5	Pounds per 1,000 gallons
Dairy pond	12.2	3.2	8.1	5.9	22.4	Pounds per 1,000 gallons
Laying hens	50.5	6.2	43.7	60.2	66.2	Pounds per ton
Turkeys	57.4	18.8	42.1	64.1	48.4	Pounds per ton
Beef	18.8	3.1	15.4	10.4	15.5	Pounds per ton
Sheep	29.1	5.9	18.2	30.6	42.1	Pounds per ton

Using data from Table 1, applying 13,000 gallons per acre of dairy pond manure to a field in the fall, applies 76.7 pounds of P205 per acre (13,000 gallons * 5.9 pounds per 1,000 gallons).

Using data from Table 1, applying two tons of laying hen poultry litter a field in the fall, applies 120.4 pounds of P205 per acre (2 tons * 60.2 pounds per ton).

Ohio State University Extension has conducted manure research on growing crops for several years in an effort to make better use of the available nutrients. Another goal of this research is to widen the manure application window to allow more days of the year for manure in-season application to growing crops.

Manure side-dress on corn

The manure research trial in Table 2 was conducted over six years at the Northwest Ohio Agricultural Research and Development Center's Hoytville station. The swine manure application rate was 5,000 gallons per acre to get 200 units of ammonia nitrogen. The dairy manure application rate was 13,577 gallons per acre to get 130 units of nitrogen. The dairy treatments received additional nitrogen as incorporated 28% UAN just prior to the manure application to reach the 200 units of nitrogen per acre goal. The 28% UAN treatments also received 200 units of nitrogen.

Pre-emergent applications of 28% UAN, swine manure and dairy manure were made within five days of corn planting. Post-emergent applications of 28% UAN, swine manure and dairy manure were made at the V3 stage of corn growth. Manure applications were made with a 2,250 gallon tanker and Dietrich toolbar with sweeps. Incorporated manure was placed at a depth of five inches. Surface manure was applied by using the Dietrich toolbar held just above ground level.

Table 2

Manure Side-dress of Corn Research Trial - Six Year Summary							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**Six-year average**
Pre-emergent treatments	**Yield bu/ac**	**Yield bu/ac**	**Yield bu/ac**	**Yield bu/ac**	**Yield bu/ac**	**Yield bu/ac**	**Yield bu/ac**
Incorporated 28% UAN	138.1	111.5	184.6	145.1	130.8	140.9	142.6
Incorporated swine manure	191.9	128.6	191.8	146.5	161.9	162.0	158.2
Surface applied swine manure	180.9	109.5	175.7	137.2	110.3	125.5	131.6
Incorporated dairy manure + 28% UAN	190.1	132.0	185.4	166.1	146.3	163.7	158.7
Surface applied dairy manure + 28% UAN	184.5	97.0	166.0	141.9	106.4	122.1	126.7

Post-emergent treatments							
Incorporated 28% UAN	132.7	116.0	181.9	140.9	140.1	145.1	144.8
Incorporated swine manure	180.8	138.4	196.7	139.9	158.5	183.7	163.4
Surface applied swine manure	178.0	116.4	188.0	115.6	114.6	153.1	137.5
Incorporated dairy manure + 28% UAN	180.0	138.8	192.0	156.9	167.5	167.7	164.6
Surface applied dairy manure + 28% UAN	170.5	101.6	181.5	125.3	111.6	156.1	135.2
Zero nitrogen check	74.4	62.6	82.0	67.0	40.2	48.7	60.1

Stand populations were approximately 31,000 plants per acre across all treatments. The manure did not appear to reduce the plot stands in any year. The 2011, 2012 and 2014 growing seasons experienced moderate to severe drought conditions and the crop in the manure treatments appeared to benefit from the moisture contained in the manure.

The incorporated manure treatments produced higher yields than the 28% UAN and the surface applied manure treatments. This is probably due to less nitrogen being lost when the manure was incorporated. Incorporation of manure can result in less nitrogen loss, less odor, and can reduce the loss of phosphorus from the fields.

A drag hose treatment was started in 2014 to determine what stand damage and potential yield loss may occur from the V1 to the V5 stage of corn. A six-inch diameter drag hose, filled with water, was pulled across each plot twice (going in opposite directions) at corn growth stages V1 through V5. The plot was replicated four times in a randomized block design.

Table 3

		2014-2018 OARDC Drag Hose Damage Corn Plot Results									
Year	2014		2015		2016		2017		2018		
Corn stage	Stand	Yield bu/ac	Stand	Yield bu/ac	Stand	Yield bu/ac	Stand	Yield bu/ac	Stand	Yield bu/ac	Five-year ave.
No drag hose	30,166	145.1	31,850	167.2	28,625	145.1	35,000	164.5	30,750	217.8	167.9
V1	29,660	154.3	31,750	166.1	28,625	149.5	35,125	161.5	31,500	218.0	169.9
V2	30,166	157.9	32,000	165.3	28,500	141.2	34,750	159.6	30,750	217.7	168.3
V3	28,933	153.9	31,375	172.3	29,250	144.4	34,875	172.1	29,625	215.6	171.9
V4	29,264	149.7	31,375	164.3	27,500	152.1	33,750	166.5	28,750	209.1	168.4
V5	15,366	109.8	23,500	123.5	16,000	126.3	25,250	122.2	18,250	132.8	122.9

The results of this five-year research study suggest corn could be side-dressed with liquid livestock manure using a drag hose through the growth stage V4 without a yield loss. More than 60% of the corn plants snapped off at the V5 stage. The plants that regrew typically did not produce reasonable ears of grain.

This study was repeated in 2019-2021 at the OARDC Hoytville station using a 4.5 inch drag hose filled with water. The thought was that perhaps a smaller, lighter drag hose would allow for manure application to corn beyond the V4 stage. The corn stages in this study were V3 to V6. The three-year results with the smaller diameter drag hose showed the same damage at the V5 stage and beyond as the larger drag hose did.

Drag lines are commonly used to apply livestock manure due to their efficiency and low potential for soil compaction. Drag hose applicators can apply 1,200 to 2,500 gallons per minute depending on distance from the manure source, size of the manure pump, the diameter of the mainline hose, and the diameter of the drag hose.

Harrod Farms in Darke County used a five-inch drag hose to apply swine finishing manure to their corn fields in the 2014-2019 growing seasons. The corn was generally at the V3 stage of growth when the manure was incorporated as a side-dress although it was just spiking the 1st year in 2014.

Table 4.

Harrod Farms Four-Year Manure Incorporation Drag Hose Corn Plots		
Year	Swine Finishing Manure	28% UAN
2019	195	168
2018	264	246
2017	165	145
2016	222	216
2015	154	121
2014	204	204
Average yield	200.6	183.3

The manure treatments averaged 13.7 bushels per acre more than the 28% UAN treatments. They incorporated approximately 6,500 gallons of swine finishing manure per acre to provide all the side-dress nitrogen. The fields received 10 gallons per acre of 28%UAN as row starter. Harrod Farms planted their corn fields at an angle to make the drag hose work. This way a hose humper, and second tractor, is not needed.

We have also conducted on-farm drag hose plots with dairy producers using dairy manure to side-dress silage corn. At an application rate of 13,000 gallons per acre, the dairy manure provided moisture and about 175 pounds of available nitrogen for the crop. At harvest time, the dairy manure silage yields averaged 24.5 tons per acre. The commercial fertilizer treatments (180 pounds of anhydrous ammonia as a side-dress) yielded 25.1 tons per acre. Manure and fertilizer were side-dressed at the V3 stage of growth.

Manure top-dress on wheat

Research on applying liquid livestock manure as a spring top-dress fertilizer to wheat has been ongoing in Ohio for several years. There is usually a window of time, typically around the last week of March or first week of April, when wheat fields are growing and firm enough to support manure application equipment.

The key to applying the correct amount of manure to fertilize wheat is to know the manure's nitrogen content. Most manure tests reveal total nitrogen, ammonia nitrogen and organic nitrogen amounts. The ammonia nitrogen is immediately available for plant growth. The organic portion takes considerably longer and generally will not be available when wheat uptakes the majority of its nitrogen in the months of April and May.

Some manure tests also list a "first year availability" nitrogen amount. This number is basically the ammonia nitrogen portion of the manure plus about half the organic nitrogen portion. Again, for wheat, the organic portion of the nitrogen should not be considered available in time to impact yields.

Most deep-pit swine finishing manure will contain between 30 and 45 pounds of ammonia nitrogen per 1,000 gallons. Finishing buildings with bowl waters and other water conservation systems can result in nitrogen amounts towards the upper end of this range. Finishing buildings with nipple waters and surface water occasionally entering the pit can result in nitrogen amounts towards the lower end of this range.

Three years of on-farm wheat top-dress results are summarized in Table 5. Each field trial was replicated four times. In each plot, the manure ammonia nitrogen application rate was similar to the nitrogen amount in the urea; typically about 100 pounds per acre. Urea was applied using a standard fertilizer buggy. The manure was applied using a 4,800 gallon tanker with a Peecan toolbar. This toolbar cuts the soil surface with a straight coulter and a boot applies the manure over the soil opening.

Table 5. On-farm Swine Manure Top-dressing of Wheat Results (bu/ac)

Year	Surface application	Incorporated	Urea	Date of Application
2009	127.5	125.4	128.2	April 7
2008	63.1	61.4	62.9	April 2
2007	102.2	98.0	95.5	March 28
Average	97.6	94.9	95.5	

*Incorporation was performed with a modified Peecan toolbar attached to a 4,800 gallon tanker. Surface application was preformed by raising the pecan toolbar above the soil surface.

In addition to the Peecan toolbar, OSU Extension as also conducted manure research on wheat using the both the Veenhuizen toolbar and Aerway toolbars. All toolbars cutting through the soil cause some disruption to the growing wheat but side-by-side yield comparisons with conventional surface applied fertilizer have rarely shown any difference in yields.

Dairy manure has also been utilized in on-farm research plots when topdressing wheat. Dairy manure contains far less ammonia nitrogen per 1,000 gallons than swine finishing manure and does not consistently produce yields similar to commercial fertilizer on wheat. However, commercial manure applicators in Ohio have applied dairy manure to wheat fields that were eventually harvested as wheatlage. This is a window of time to apply manure to a growing crop to maximize the manure nutrients.

Livestock manure can also be applied in the fall as a starter source of nitrogen for the wheat crop. Livestock producers commonly apply manure prior to planting wheat and incorporating the manure with tillage. Livestock producers also commonly surface apply manure and either plant wheat through the surface applied manure or surface apply the manure after the wheat is planted. The wheat emerges through the manure. This can work for cover crops as well.

Balancing for crop removal

Knowing the crop removal rates of harvested crops is an important piece of the puzzle when balancing manure and fertilizer inputs for a field. Table 6 from OSU Extension Bulletin 974 shows the nutrients removed by the various crops.

Table 6.
Tri-State Fertilizer Recommendations for Corn Soybeans Wheat and Alfalfa: Bulletin 974 Table 15

Nutrients Removed in Harvested Portions of Agronomic Crops			
Crop	Unit of Yield	Nutrients (pounds) removed per unit of Yield	
		P_2O_5	K_20
Corn	bushel	0.35	0.20
Corn silage	ton	3.1	7.3
Soybeans	bushel	0.80	1.15
Wheat	bushel	0.50	0.25
Wheat straw	ton	3.7	.29
Alfalfa	ton	12.00	49.0

Using data from Table 1, applying 6,000 gallons per acre of swine finishing manure to a field in the fall, applies 108.6 pounds of P205 per acre (6,000 gallons * 18.1 pounds per 1,000 gallons). If the field yields 175 bushels of corn the following year, 63 pounds of P205 is removed (175 bushels * 0.35 pounds of P205 per bushel). A 55 bushel soybean crop the following year would remove an additional 44 pounds of P205 (55 bushels of soybeans 0.80 pounds of P205 per bushel). Thus, the two-year crop rotation utilized 107 pounds of the 108.1 pounds of P205 applied. No additional phosphorus fertilizer would be needed if the field was already in the maintenance range for phosphorus.

Properly applying manure to farm fields is important to keep fields available for additional manure applications in future years. To capture the most nutrients from manure farmers should consider incorporation. Incorporation can result in less nitrogen loss and can especially reduce the loss of dissolved reactive phosphorus.

MASARATH ALKHAILI, UNSPLASH

Fertilizer Math

One of the challenges in making a nutrient and fertilizer recommendation is paying close attention to the units used in the results received from testing laboratories. There is no single reporting standard. For example, soil tests may be reported as parts per million or pounds per acre. Manure test may have phosphorus reported as P (elemental P) versus P_2O_5 (phosphate).

Fertilizer "guaranteed analysis" standards are defined in Ohio revised code. The reporting format for fertilizer is Total N (percent)-available phosphate expressed as P_2O_5 (percent)-soluble potash expressed as K_2O (percent). All items are listed in that order on the material label.

When you review reports, take a few minutes to look closely at the units reported for each measure. If a report form has units you do not recognize, check with the originating lab for an explanation of the units plus conversion equations. This will allow you to convert the test results and a nutrient recommendation into the same methods and units.

FERTILIZER LABEL EXAMPLE

ALL-PURPOSE
FERTILIZER

12-12-12

GUARANTEED ANALYSIS

Total Nitrogen (N) 12%

4.7% Ammoniacal Nitrogen
7.3% Urea Nitrogen

Availablle Phosphate (P_20_5) 12%

Soluble Potash (K_20) 12%

Derived from: Ammonium Phosphate, Urea, and Muriate of Potash.

Common conversions and other fertilizer math

A. Conversion between parts per million (PPM) and pounds per acre is often needed for soil test interpretation. For example, a soil test may be reported in pounds per acre, but the relevant recommendation table may use parts per million (PPM) as the units.

Equation	Example
PPM × 2 = pounds per acre	40 PPM × 2 = 80 pounds per acre
Pounds per acre ÷ 2 = PPM	80 pounds per acre ÷ 2 = 40 PPM

B. Conversion between elemental phosphorus (P) and phosphate (P_2O_5). Manure analysis can have the phosphorus content listed as elemental P, but fertilizer recommendations are always reported as the phosphate form. Be sure to convert to phosphate or you will be over applying phosphorous.

Equation	Example
Pounds P × 2.29 = pounds of P_2O_5	26 pounds P × 2.29 = 60 pounds of P_2O_5
Pounds of P_2O_5 × 0.44 = pounds of P	60 Pounds P_2O_5 × 0.44 = 26 pounds of P

C. Conversion between elemental potassium (K) and potassium oxide (K_2O). Manure analysis can have the potassium content listed as elemental K, but fertilizer recommendations are always reported as the potassium oxide form. Be sure to convert to potassium oxide or you will be over applying potassium.

Equation	Example
Pounds K × 1.21 = pounds of K_2O	54 pounds K × 1.21 = 65 pounds of K_2O
Pounds of K_2O × 0.83 = pounds of K	65 pounds K_2O × 0.83 = 54 pounds of K

D. Use the following equation to determine pounds of nutrient applied when dry fertilizer materials are used.

Equation	Example: 100 pounds of material with an analysis of 15-28-15
Pounds of material × (% N ÷ 100) = pounds N	100 × 0.15 = 15 pounds N
Pounds of material × (% P_2O_5 ÷ 100) = pounds P_2O_5	100 × 0.28 = 28 pounds P_2O_5
Pounds of material × (% K_2O ÷ 100) = pounds of K_2O	100 × 0.15 = 15 pounds K_2O

E. Equation to determine the pounds of nutrient in a liquid fertilizer source. A common per-gallon-weight of many liquid fertilizers is 11 pounds per gallon (water weighs 8.3 pounds per gallon). The label should provide a weight per gallon.

Equation	Example: Three gallons of 10.4 pound per gallon material with analysis of 0.2-0.6-1.7
Gallons of material × material weight per gallon × (% N ÷ 100) = pounds of N	3 × x 10.4 × 0.002 = 0.06 pounds N
Gallons of material × material weight per gallon × (% P_2O_5 ÷ 100) = pounds of P_2O_5	3 × 10.4 × 0.006 = 0.19 pounds P_2O_5
Gallons of material x material weight per gallon x (% K_2O ÷ 100) = pounds of K_2O	3 × 10.4 × 0.017 = 0.53 pounds K_2O

F. Formula for nutrient recommendation to be met in a single application. The formula results in the needed amount of fertilizer material (11-52-0) to meet the nutrient need of 50 pounds P_2O_5.
NOTE: We are applying 10 pounds of N (96 pounds × .11) in the application as well.

Equation	Example: How many pounds of 11-52-0 are needed for 50 pounds of P_2O_5 recommendation?
Nutrient need in pounds ÷ (% nutrient in analysis/100) = pounds of material	50 ÷ (52 ÷ 100) = 96 pounds of 11-52-0

G. Calculating the cost per pound of nutrient in a fertilizer source.

Equation	Example: Cost per unit of N in 28-0-0 at $250 per ton?
Cost per ton ÷ (2000 × (% nutrient in analysis/100)) = pounds of material	250 ÷ (2000 × (28 ÷ 100)) = 0.45 cents per unit of N

Ohio Agricultural Fertilizer Applicator Recordkeeping Form

Maintain records for 3 years from the date of application.

Who - Name of Certificate Holder:

Name of Applicator (*if different than above*):

When: (mm/dd/yyyy)							
Application Date							
Where:							
Location							
What:							
Fertilizer analysis							
Rate applied							
Type of application method							
Application Conditions:							
Soil Conditions							
Air Temperature							
Precipitation							
Soil frozen or snow covered (Y/N)							
Weather Forecast:							
24 hour forecast following application							

Notes:

Certified Agricultural Fertilizer applicators in Ohio have two options to keep their certification current:

- Attend 1 hour of approved fertilizer recertification training sessions anytime during the 3 year period.
- **Or** take ODA fertilizer exam every 3 years

You MUST completely fill out and sign your recertification form to receive credit.

You also must send in your application and $30 renewal fee to ODA to renew your fertilizer certificate every three years. If you have both pesticide and fertilizer certification, you only pay a single fee for the pesticide license ($30).