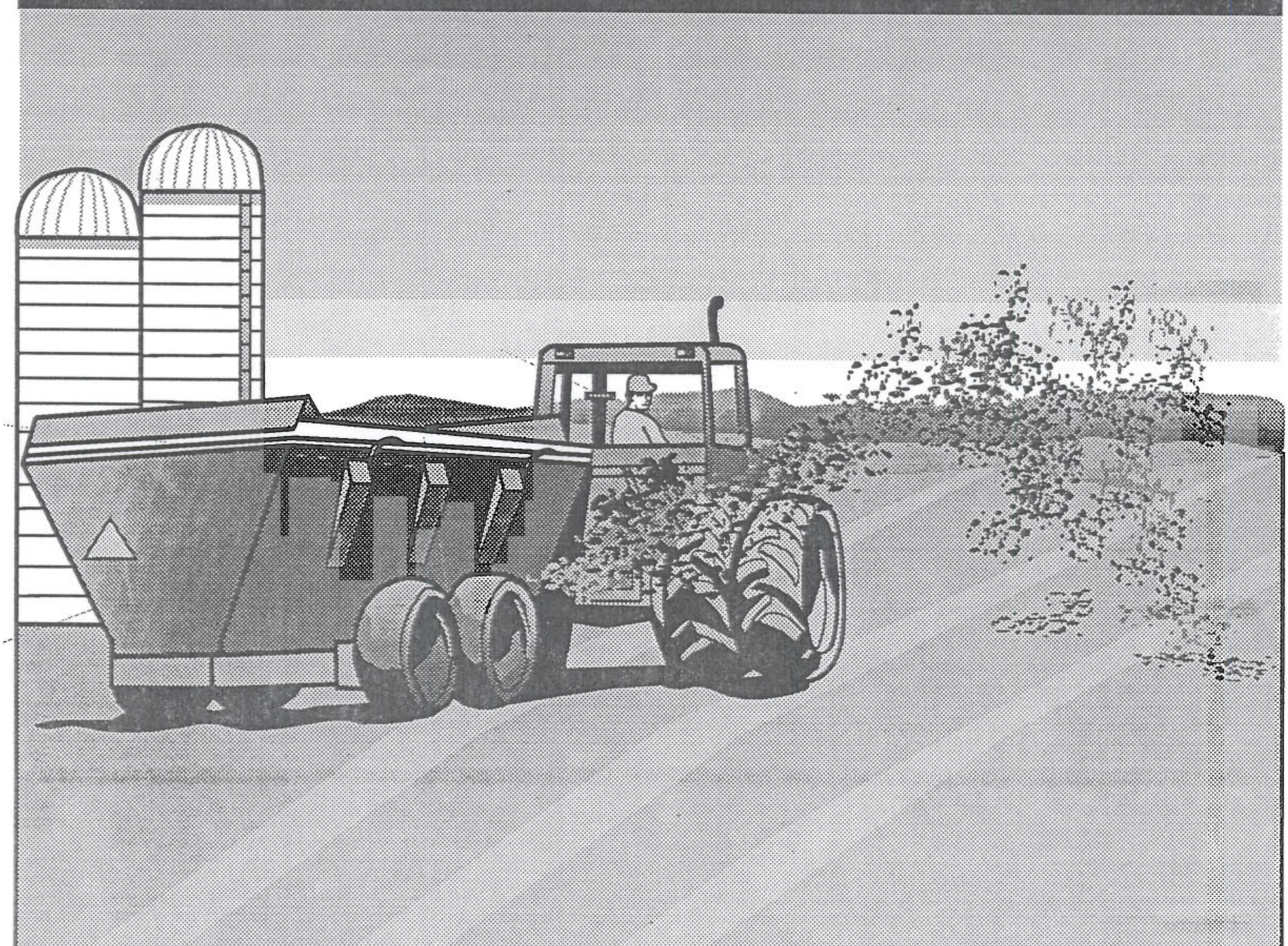
THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXTENSION SERVICE

PB 1510

Manure Application Management



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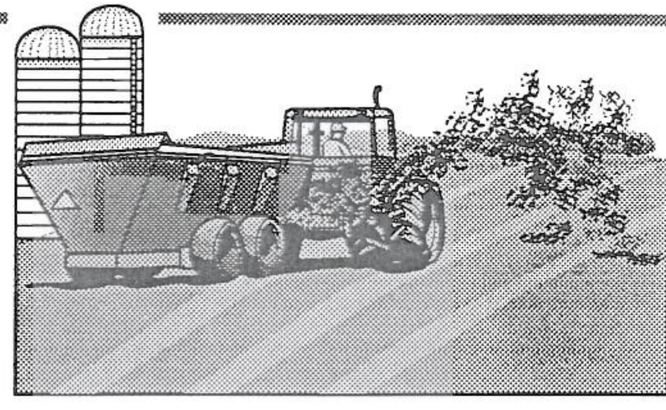

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Introduction

Our soils often benefit from the addition of organic materials. Land application of animal manures provides an excellent way to utilize these organic materials both as a soil conditioner and a nutrient resource.

Improvements in soil volume, chemical and physical properties from the addition of organic materials are somewhat difficult to place in a dollar value category but are nevertheless real, especially when considered on a long-term basis.

Manures supply the three primary plant nutrients: Nitrogen (N), Phosphorus (P_2O_5) and Potassium (K_2O). A real dollar value can be placed upon the nutrient content of manures when applied to correct a nutrient deficiency.

Additional savings are realized by not having to dispose of these materials in some other, more costly manner.

As with any fertilizer source, consideration of proper application rates is necessary to ensure the most cost effective and environmentally sound results. Too little can result in the need for supplementary inorganic fertilizer to avoid loss of production. Excessive manure application rates or other factors including improper storage, poor site selection or improper timing of application may greatly increase the potential for nutrients to escape into our surface or ground waters. This publication assumes proper storage, site selection and application timing, and deals primarily with the determination of manure application rate to meet crop nutrient requirements.

Nutrient Requirements

The first step in any nutrient management program is to determine crop nutrient requirements. Soil testing is commonly accepted as a reliable means of identifying crop nutrient needs and can provide a basis for economically and environmentally sound fertilizer application rates.

Manure application rates are usually based on the crop nitrogen requirement. For low analysis manures, supplemental nitrogen may be needed. Manure application rates should never exceed the crop nitrogen requirement. Annual manure application rates and timing of applications may be restricted by and should never exceed or vary from those listed in Conservation Compliance Plans as based on site-specific environmental considerations.

When phosphorus or potassium tests high or very high, additional fertilization with the nutrient which tests high or very high is usually not needed or recommended. To avoid building nutrient levels of soils testing high or very high in phosphorus or potassium, it may be desirable to calculate manure application rate on the basis of crop phosphorus or potassium removal. Table 1 provides a list of estimated nutrient removal per unit of yield for many Tennessee crops. Actual removal will be site-specific and may be most accurately determined by a laboratory analysis of a representative sample of the plant material removed from the field.

Nutrient Availability

The nutrients contained in animal manures, composts or other organic materials are much less readily available to plants than the nutrients of most of our inorganic fertilizers. Also, nutrient content of these materials may be highly variable (Table 2).

Nitrogen: Manure is a "slow release" nitrogen fertilizer. Approximate manure nitrogen availability percentages for Tennessee soils and environmental conditions are listed in Table 3. They vary according to the type of material, storage and method of application. When incorporated, most of the ammonium nitrogen is available to the crop during the first year. Nitrogen availability percentages listed in Table 3 account for ammonium nitrogen content of the various materials. Therefore, they represent the percentage of total N available for crop growth in the first year after spring application of manure.

When ammonium nitrogen content is known (from results of manure test), assume that it is 90 percent available if the material is incorporated into the soil within 12 hours of application. Use the percentages listed under column 1 of Table 3 to determine the availability of organic nitrogen during the first year following a spring application.

Organic N (Total N minus ammonium N, or assume 60 to 75 percent of the Total N as organic) will contribute nitrogen to the cropping system over a period of years. To estimate this residual N, use the availability coefficients listed in Table 4.

Phosphorus and Potassium: Approximately 75 to 100 percent of the total phosphorus and potassium content of manures and composts will be available to the crop within the year of application. Any residual value of the phosphorus and potassium applied in these materials will be accounted for by increased soil test P and/or K values.

Determining Priority Nutrient and Fertilizer Needs

Worksheet 1 provides a step-by-step procedure for determining net crop nutrient needs. Credits are given for starter or other fertilizer additions, residual nitrogen from previously applied manures and legume-supplied nitrogen. Nitrogen is usually selected as the priority nutrient and total crop nutrient needs are determined on the basis of soil test results. When soils test high or very high in phosphorus or potassium, it may be desirable to use the nutrient which tests high or very high as the priority nutrient for determining manure application rate. Also, when manures test low in Total N, basing application rate on phosphorus or potassium may be desirable. In any situation, manure application rate should never exceed the crop's nitrogen requirement.

No fertilizer recommendation is made when a soil tests very high in phosphorus or potassium. Amounts of these nutrients that can be added from manure without greatly affecting soil test values are commonly estimated on the basis of expected crop removal. Values in Table 1 may be used to estimate crop removal expected per unit of yield for various crops.

For example, one ton of Coastal Bermudagrass hay will remove seven pounds P_2O_5/acre. The P_2O_5 maintenance requirement (fertilizer need for maintaining but not increasing soil test levels) would be at least seven pounds P_2O_5/acre/ton of expected yield. For an expected annual yield of six tons/acre, at least 42 lbs P_2O_5/acre (six tons hay **X** seven pounds P_2O_5 removed/ton hay) could be added as manure without a significant change in soil level of P_2O_5.

Net nutrient needs are reported as the difference between soil test identified needs and credits listed on worksheet 1.

Determining Manure Application Rate

Worksheet 2 allows for the calculation of the manure application rate needed to satisfy the need for the nutrient identified as the priority nutrient (N, P_2O_5 or K_2O). Also calculated are the total amounts of nutrients supplied (pounds per ton or 1,000 gallons) at the manure application rate determined necessary to meet the need for the priority nutrient.

These calculations are most reliable when based upon a laboratory analysis of the manure. Many laboratories report phosphorus and potassium as pounds of P and K per ton or per 1000 gallons. To use these values with The University of Tennessee soil test fertilizer recommendations, it's necessary to convert them to an oxide basis (P_2O_5 and K_2O). To change these elemental values to the oxide, use: P X 2.29 = P_2O_5 or K X 1.2 = K_2O (pounds of nutrient per ton of totally dried manure). Also, many laboratories only report results on a dry matter basis. Multiply values reported on a dry matter basis by the percentage dry matter (1 - percentage moisture) to convert them to an "as-spread-in-your-field" basis. For example, if the manure contains 30 pounds of N per ton and has 20 percent moisture (1 - 0.2 = 0.80 dry matter), then the pounds of N per ton as spread = 0.80 X 30 = 24.

If a laboratory analysis is not performed, Table 2 may be used to estimate the nutrient content of the manure. However, the values listed in Table 2 are only approximate values. Actual value can vary as much as 100 percent, therefore it is always best to rely upon a laboratory analysis. Manure application rate can then be determined on the basis of the net need for the priority nutrient (usually nitrogen) as identified in part 8 A, B, C, D or E of worksheet 1. Nutrient balance and supplemental fertilizer needs are calculated as the difference between nutrients supplied at the calculated manure rate and net nutrient need (identified in worksheet 1).

Summary of Nutrient Balance on Whole Farm Basis

Worksheet 3 allows for the summary of manure applied, net nutrient needs, total manure nutrient credits and supplemental fertilizer needs on a whole farm basis. Savings from manure-supplied fertilizer can then be determined on a whole farm basis by multiplying total pounds/acre nutrient credit (up to the amount indicated under net nutrient need) for each nutrient by the number of acres and the current price per pound of nutrient and summing the results.

From the example on worksheet 1 (part 8 A, B, C) net nutrient needs were 88 lbs N/acre, 100 lbs P_2O_5/acre and 100 lbs K_2O/acre. Worksheet 2 calculates that 2.9 tons of dry pit poultry manure supplies 88 lbs N/acre, 129 lbs P_2O_5/acre and 70 lbs K_2O/acre. All of the N and K_2O can be considered necessary, but only 100 of the 129 lbs P_2O_5 was called for by the soil test and calculation of net nutrient needs. Therefore 29 pounds of P_2O_5 is extra and should not be included in a calculation of dollars saved from fertilizer purchase. Total fertilizer savings realized on a per acre basis would be: (88 lbs N X price per lb N) + (100 lbs P_2O_5 X price per lb P_2O_5) + (70 lbs K_2O X price per lb K_2O).

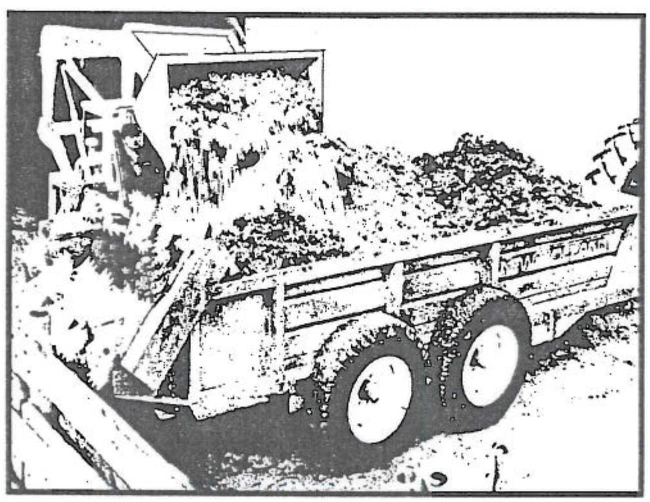

Table 1. Nutrient Removal by Crops

		Approximate Pounds per Acre of Nutrients Removed by the Portion of Crop Shown		
Crop	Unit	N	P_2O_5	K_2O
CORN				
Grain	Bu	1.00	0.37	0.26
Stover	—	0.75	0.15	1.06
Total		1.75	0.52	1.32
SOYBEANS				
beans	Bu	4.00	0.80	1.40
stems,leaves	--	1.15	0.27	0.96
Total		5.15	1.07	2.36
COTTON				
lint and seeds	Lb	0.02	0.01	0.01
stems,leaves	--	0.01	0.004	0.01
Total		0.03	0.014	0.02
WHEAT				
grain	bu	1.25	0.62	0.37
straw	--	0.57	0.15	0.90
Total		1.82	0.77	1.27
TOBACCO				
leaf	lb	0.03	0.006	0.05
stalk	lb	0.01	0.006	0.03
Total		0.04	0.012	0.08
GRAIN SORGHUM				
grain	bu	0.83	0.41	0.21
stover	--	0.94	0.18	1.06
Total		1.77	0.59	1.27

Table 1. Continued. Nutrient Removal by Crops

Crop	Unit	Dry Matter (%)	Approximate Pounds per Acre of Nutrients Removed by the Portion of Crop Shown		
			N	P_2O_5	K_2O
HAY	Ton				
Alfalfa (early bloom		89.2	52	9	43
Alfalfa (full bloom)		89.2	41	9	43
Mostly Legume		89.2	34	9	37
Coastal Bermuda		89.0	26	7	23
Ryegrass		89.0	28	10	30
Ladino Clover		91.2	67	16	47
Red Clover		87.7	42	10	35
Fescue		88.5	28	10	34
Lespedeza		93.2	40	10	23
Oats		88.2	26	8	30
Orchardgrass		88.3	31	11	44
Sudangrass		88.9	31	8	32
Soybean		87.6	39	9	20
Timothy		88.4	27	7	34
Vetch		88.2	54	10	44
Wheat		85.9	25	7	31
Peanut		90.6	32	7	30
SILAGE	Ton				
Alfalfa		28.0	15	4	17
Barley		35.0	12	4	14
Corn		35.0	8	3	8
Grass-Legume		45.0	16	5	16
Oats		35.0	11	4	15
Grain Sorghum		30.0	8	2	9
Forage Sorghum		30.0	7	2	7
Sudangrass		35.0	10	3	14
Soybean		30.0	17	7	7
Timothy		37.5	11	3	14
Wheat		35.0	10	3	10
Rye		33.0	12	3	14

Sources: Our Land and Its Care[1], DART Ration[2]

Table 2. Approximate Manurial Nutrients Remaining at Time of Application.[1]

Species	System	Solids (%)	N	P_2O_5[2/]	K_2O[3/]	N	P_2O_5	K_2O
			Lbs./Ton			Lbs./1000 Gals.		
Dairy Cattle	Daily Spread	15	8	5	10	—	—	—
	Anaerobic pit	8	—	—	—	24	18	29
	Earthen Storage	10	—	—	—	32	14	28
	Anaerobic Lagoon	1	—	—	—	4	5	5
	Above Ground Storage	12	—	—	—	46	18	40
	Covered Stack	18	10	9	12	—	—	—
Swine	Anaerobic Pit	4	—	—	—	36	27	19
	Anaerobic Lagoon	1	—	—	—	4	2	4
Beef	Open Feedlot	15	10	7	10	—	—	—
Poultry	Liquid Pit	13	—	—	—	80	37	96
	Dry Pit (dry)	85	100	70	40	—	—	—
	Dry Pit (Crumbly)	70	60	55	30	—	—	—
	Dry Pit (Moist)	50	40	40	20	—	—	—
	Dry Pit (Fresh, Wet)	25	30	20	10	—	—	—
	Compost	54	44	66	48	—	—	—
Sheep	Dry Pit	25	23	8	20	—	—	—
Horse	Dry Pit	20	12	5	9	—	—	—
Municipal Sludge	Earthen or Above Ground Storage	4	—	—	—	14	17	2
Composted Municipal Materials	Dry Pit	70	20	60	4	—	—	—
Composted Poultry Materials	Dry Pit	54	44	66	48	—	—	—

1/ Sources: Pennsylvania Manure Management Manual (Draft)[3], The Value and Use of Poultry Waste as Fertilizer[4], Chicken Manure-Its Production, Composition and Use as Fertilizer[5], Utilization of Organic Wastes on Agricultural Soils of Tennessee[6], Animal Waste Utilization on Cropland and Pastureland[7] **Actual values may vary as much as 100 percent, therefore it's best to rely on laboratory analysis whenever possible.**

2/ $P \times 2.29 = P_2O_5$ or $P_2O_5 \times 0.43 = P$

3/ $K \times 1.2 = K_2O$ or $K_2O \times 0.83 = K$

Table 3. Nitrogen Availability Coefficients for Manure Total Nitrogen Content

Type of Manure	Method of Incorporation				
	Column 1	Column 2	Column 3	Column 4	Column 5
	Broadcast, No Incorporation	Broadcast, Incorporated within 12 hours	Sweep Injected	Knife Injected	Irrigated, No Incorporation
1.Dairy (semi-solid)	0.40	0.60	---	---	---
2.Dairy (slurry)	0.45	0.60	0.70	0.70	0.45
3.Beef	0.40	0.60	---	---	---
4.Swine (slurry)	0.40	0.60	0.70	0.70	0.40
5.Swine (lagoon)	0.50	0.80	0.85	0.85	0.50
6.Poultry	0.50	0.60	---	---	---
7.Municipal sludge	0.50	0.50	0.50	0.50	---
8.Composted materials	0.20	0.20	---	---	---

Sources: Utilization of Organic Wastes on Agricultural Soils of TN[6], Agri-Waste Management[8], Virginia Water Quality Laboratory[9]

Table 4. Residual Availability of Organic N in Manures and Compost.

Material Applied	Organic N[1] Availability Coefficients
Last Year	0.13
2 Years Ago	0.05
3 Years Ago	0.02

1/ Organic N = Total N minus Ammonium N (when Ammonium N is not measured, assume that Organic N is 60 to 75 percent of the Total N).

Example:

1. 5 tons/acre applied last year with 60 pounds Total N per ton
   Organic N = 0.70 X 60 = 42 pounds/ton X 5 tons = 210 lbs organic N per acre
2. 6 tons/acre applied 3 years ago and also having 60 pounds total N per ton
   Organic N = 0.70 X 60 = 42 pounds/ton X 6 tons = 252 lbs organic N per acre
3. **Residual N Available this year= (210 X).13) + (252 X 0.02) = 27+ 5 = 32 lbs N/acre.**

Worksheet 1.

Determining Fertilizer Needs

	Example	Your Situation
1. Crop to be Grown	corn for grain	
2. Date Crop to be established	Spring 19___	
3. Field number or description	Field A1	
4. Total Fertilizer Needs (From soil test report). If P_2O_5 or K_2O is the priority nutrient then estimate maintenance from Table 1.		
A. Nitrogen (lbs N/acre)	120	
B. Phosphorus (lbs P_2O_5/acre)	100	
C. Potassium (lbs K_2O/acre)	100	
5. Fertilizer Applied/Starters to be applied (lbs nutrient/acre)		
A. N	0/0	
B. P_2O_5	0/0	
C. K_2O	0/0	
6. Residual Nitrogen from Materials applied in previous years. (lbs. Organic N X factor from table 3, see ex. below table 3.		
A. N from last years application (lbs. organic N per acre X 0.13)	27	
B. N from application 2 years ago (lbs. organic N per acre X 0.05)	0	
C. N from application 3 years ago (lbs. organic N per acre X 0.02)	5	
D. Total Residual N (add 6a, b,c)	32	
7. Residual N credits for legumes		
A. Crimson Clvr. or Hairy Vetch Green Manure (50 to 70 lb N/acre)	0	
B. Good Alfalfa stand, 70 to 100 %, more than 4 plants/ft^2 (160 lb N/acre first year credit or 50 lb N/acre second year credit)	0	
C. Fair to Poor Alfalfa stand, 30 to 70% or 1.5 to 4 plants/ft^2 (130 lb N/acre first year credit or 50 lb N/acre second year credit)	0	
D. Soybeans (1 lb N/acre/bu. beans harvested up to max. of 20)	0	
E. Other (list)	0	
8. Net Nutrient Needs		
A. Nitrogen (4A minus 5A minus 6D minus 7A or B or C or D or E)	120 - 0 - 32 = 88	
B. Phosphorus (4B minus 5B)	100 - 0 = 100	
C. Potassium (4C minus 5C)	100 - 0 = 100	
D. Lime (From your soil test report) Tons/acre	0	
E. Micronutrients (From your soil test report) Lbs/acre	0	
F. Other	0	

Worksheet 2.

Determining Manure or Compost Application Rate, Nutrient Balance and Supplemental Fertilization Based on Net Nutrient Need Identified from Worksheet 1.

	Example	Your Situation
1. Field # or Description from worksheet 1	Field # A1	
2. Calculate Available Nutrients in Manure (lbs. of nutrient per ton or per 1000 gal) to be applied this Spring. Use lab analysis or less reliably, estimated values listed in table 1.	Spring, 19__	
A. Nitrogen (lb Total N/ton or 1000 gal X Avail. Coefficient (table 3). When ammonium N analysis is available assume an avail. coef. of 0.90 for ammonium N and use avail. coef. in column 1 of table 2 for organic N (Total N minus Ammonium N)	60 lbs N/T dry pit poultry X 0.50 = 30 lbs available N/Ton	
B. Phosphorus (lb P_2O_5/ton or 1000 gal X 0.80) lbs P X 2.29 = lbs P_2O_5	55 lbs P_2O_5/T X 0.80 = 44 lbs P_2O_5/Ton	
C. Potassium (lb K_2O/ton or 1000 gal X 0.80) lbs K X 1.2 = lbs K_2O	30 lbs K_2O/T X 0.80= 24 lbs K_2O/Ton	
D. Other (List)		
E. Other (List)		
3. Determine Manure Application Rate (Tons or 1000 Gal./Acre)		
A. Priority Nutrient	Nitrogen	
B. Amount Needed (from 8a,b or c of worksheet 1, lbs nutrient/acre)	88	
C. Rate of Manure or Compost (3b/2a,b or c, Tons or 1000 Gal./Acre)	88/30 = 2.93	
4. Total Manure Nutrient Credits Calculated (Lbs./Acre)		
A. N (3C X 2A)	88	
B. P_2O_5 (3C X 2B)	129	
C. K_2O (3C X 2C)	70	
D. Other (List)		
E. Other (List)		
5. Nutrient Balance and Supplemental Fertilizer Needs (Lbs./Acre) (-) indicates need (+) indicates excess	Field: A1	
A. N (4A minus 8A from worksheet 1)	88 - 88 = 0	
B. P_2O_5 (4B minus 8B from worksheet 1)	129 - 100 = +29	
C. K_2O (4C minus 8C from worksheet 1)	70 - 100 = -30	
D. Lime (8D from worksheet 1)	0	
E. Micronutrients (8E from worksheet 1)	0	
F. Other (8F from worksheet 1)	0	

Worksheet 3. Summary of Nutrient Balance/Needs on Whole Farm Basis

Field	Crop	Date Spread	No. of Acres	Manure applied (tons or 1000 gal.)		Net Nutrient Needs Lbs./A or field			Total Manure Nutrient Credits Lbs./A or field			Supplemental Fertilizer Needs Lbs./A or field			Savings Realized When Needed Nutrients are Supplied by Alternate Sources[1]		
				per acre	per field	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Totals																	

1/ Determine savings from alternative fertilizer sources for each nutrient by multiplying total Lbs./Acre nutrient credit (up to the amount indicated under net nutrient need) for each nutrient by the number of acres and by the current price per pound of nutrient.

References:

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