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BROILER LITTER AS A SOURCE OF N FOR COTTON

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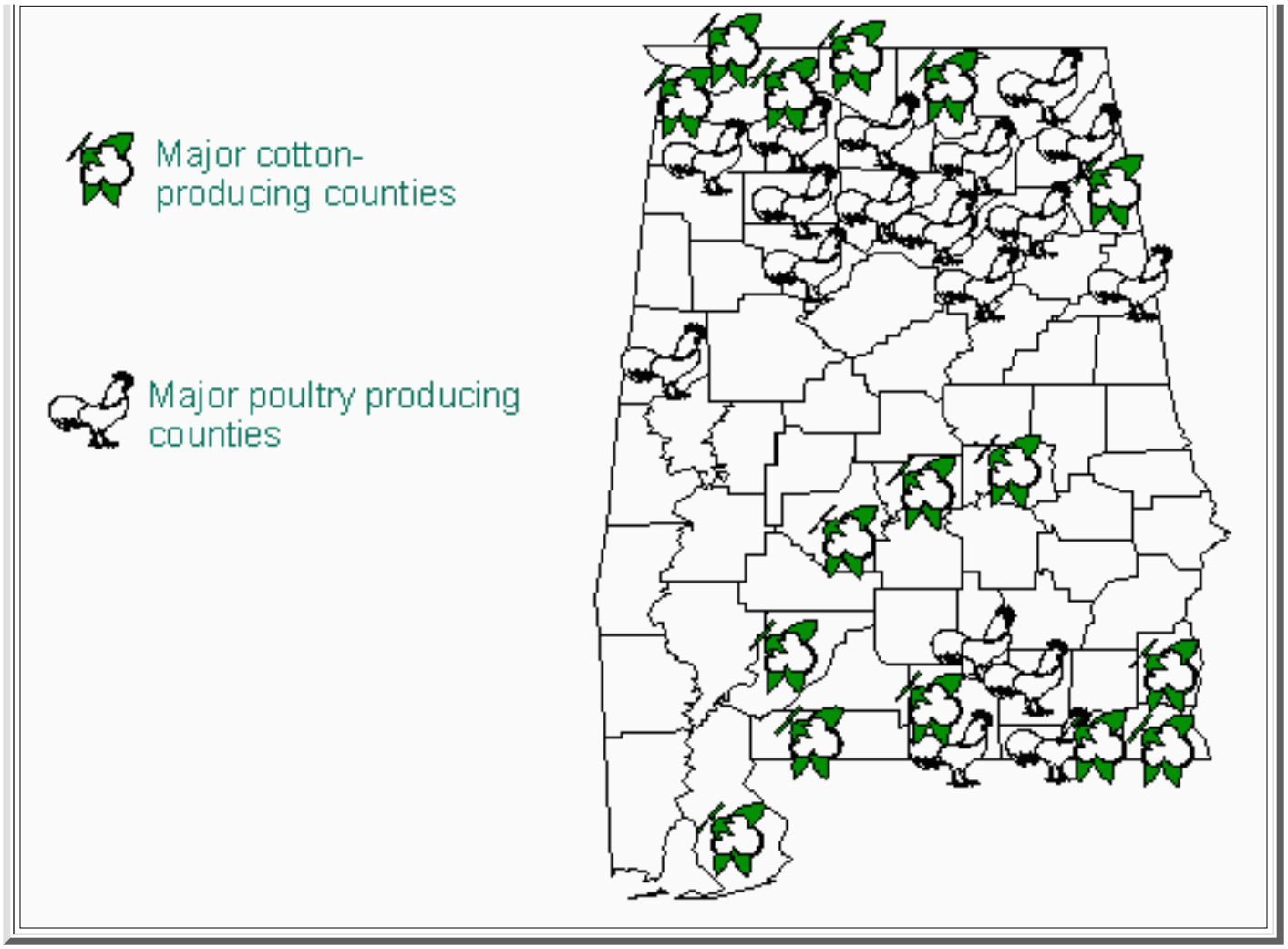
Broiler litter has been successfully used on grass crops where precise nitrogen (N) fertilization is not necessary for optimum production. However, managing N fertility for cotton is critical to achieving maximum lint yields without risk of excessive vegetative growth from high soil N. Maximizing N use by crops is also important to minimize the environmental risks of excessive N application to agricultural lands.



More than 195,000 acres of cotton are produced in the northern third of Alabama where the poultry industry is also concentrated. In the Tennessee Valley, cotton is the major consumer of fertilizer N. Cotton acreage is also increasing in South Alabama and South Georgia where broiler production is increasing. This situation creates a potential for use of boiler litter as a source of N (and other nutrients) for cotton. This could lower the cost of production for cotton producers and lower the environmental risks where broiler litter disposal rates have traditionally been applied to Appalachian Plateau soils.

On-farm tests/demonstrations in North Alabama and research at the Tennessee Valley Substation (TVS) in northern Alabama on a Decatur silty clay loam and at E. V. Smith (EVS) Research Center in Central Alabama on a Norfolk fine sandy loam since 1990 have demonstrated the practicality of using broiler litter as a source of N for cotton. **(See Table 1.).**

Broiler Litter Composition

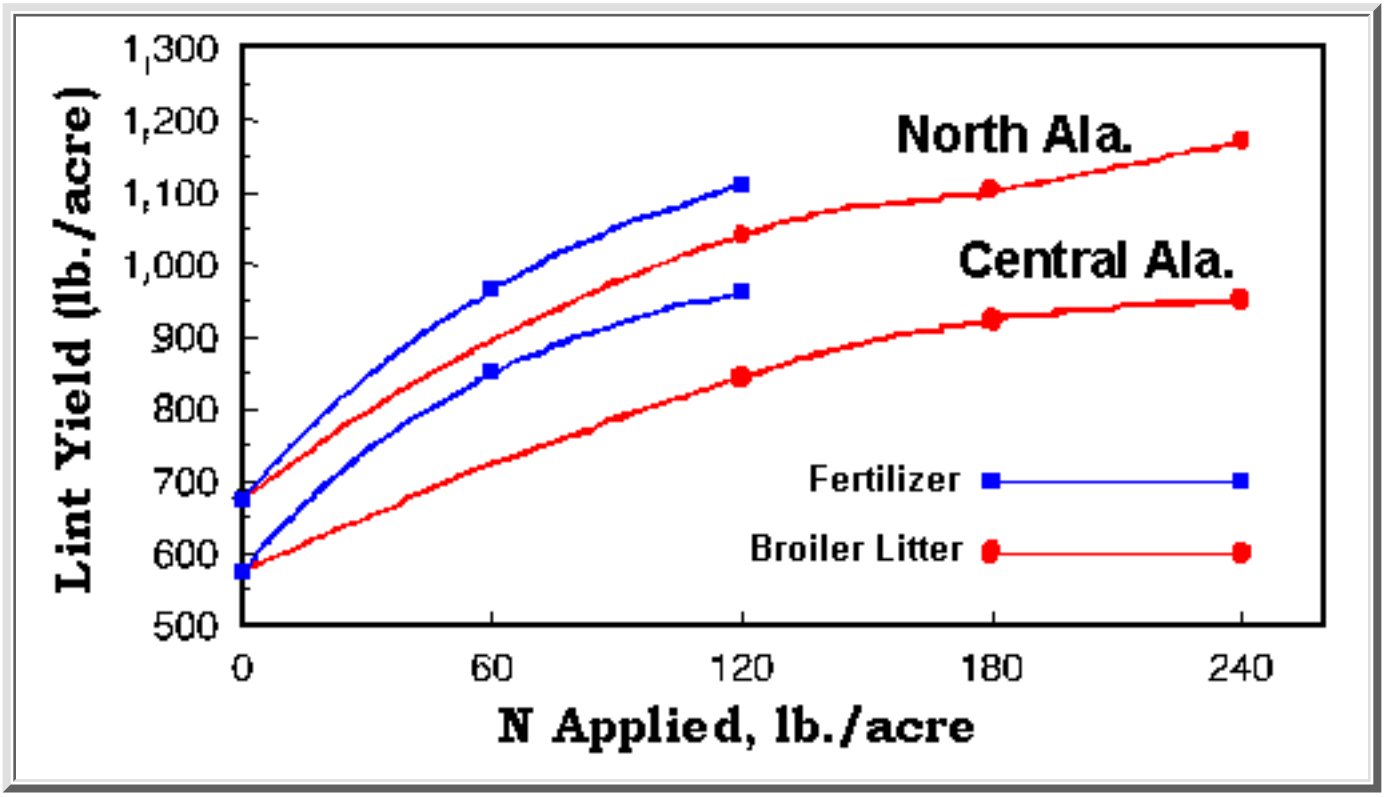
Fresh broiler litter averages about a 3-3-2 fertilizer, i.e. about 60-60-40 pounds N-P_2O_5-K_2O per ton. Most litter is used for its N value. When this is done, adequate P and K are usually applied for most situations except for soils testing very low in P and/or K. Nitrogen is the difficult nutrient to manage. Traditional reasoning is that not all of the nitrogen (N) in broiler litter is plant available since

considerable N is tied up as organic compounds and some of the inorganic N (as ammonia) is lost when surface applied. Therefore, when using broiler litter for its N content, we generally assume about 2/3 of the total N will be plant available the year it is applied (**Ala. Coop. Ext. Cir. ANR-244**). Research suggests this is a very liberal approach to N fertilization but not unreasonable.

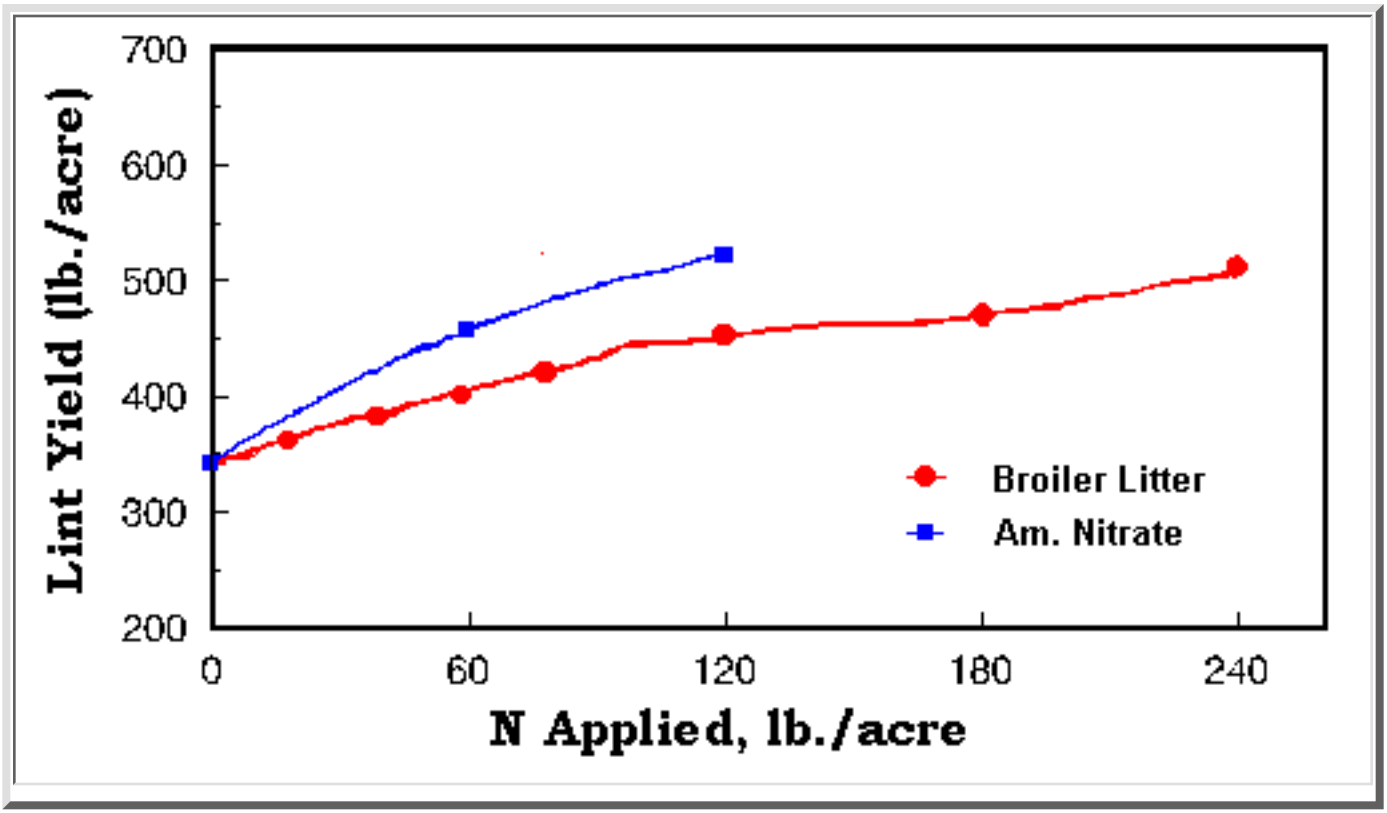
Rates Needed for Cotton

Surprisingly, most of the Alabama research has shown that pound for pound, the TOTAL N in broiler litter is only slightly less effective as the N in ammonium nitrate fertilizer (**Fig. 1**,**2**). A standard N recommendation for non-irrigated, Alabama cotton is 90 pounds total N per acre per year. Recommendations are that this be increased or decreased 30 pounds depending upon the soil, yield potential, and previous experience. Therefore, 2 tons per acre of average broiler litter (3-3-2 fertilizer) will provide 120 pounds total N, 120 pounds total P_2O_5, and 80 pounds total K_2O. If only 2/3 of the total N is actually available, this leaves 80 pounds N per acre which is within the standard recommendation.

- **Fig. 1.** Average cotton lint yields from 3-yr research at the Tennessee Valley Substation (North Alabama) and 4-yr at E.V. Smith Research Center (Central Alabama). Note that broiler litter was almost as effective as a source of N for cotton as ammonium nitrate fertilizer.



- **Fig. 2.** Average yields of two, replicated on-farm tests with broiler litter and cotton in North Alabama in 1990 (from Mitchell et al., 1992).



Time of Application

Split N applications are recommended for cotton in Alabama with most of the N applied prior to early bloom. Nevertheless, many growers, especially in North Alabama, apply all of the N at planting. In the Alabama research reported here, all of the broiler litter was applied at planting and lightly incorporated, usually with a field cultivator just prior to planting. This is both practical and economical. Applying broiler litter more than 1 month prior to planting is very risky. Spring rains could result in much of the readily available N leaching or denitrifying in Alabama soils.

Excessive Vegetative Growth

One would expect that over applying broiler litter would lead to excessive vegetative growth, late maturity, boll rot, and poor yields. **RESEARCH DID NOT INDICATE THIS**. Nitrogen rates as high as 240 pounds N per acre applied as broiler litter (approximately 4 tons per acre per year) did not reduce yields (Fig. 1,2). High rates of broiler litter resulted in greener plants and slightly later maturity, but did not reduce yields. Pix® (mepiquot chloride) was applied to a duplicate set of broiler litter and fertilizer treatments. In 1992 at the TVS location (1 out of 7 site years), Pix resulted in significantly higher yield over all treatments but the yield increase from Pix was not due to broiler litter or N rates. In general, broiler litter at N rates up to 240 pounds N per acre did not decrease yields, and Pix was unnecessary to control excessive growth.

Nitrogen Carryover and the Residual Effects

There is a residual effect or carryover of N from one year to the next where broiler litter is applied, but from a practical standpoint, the effect on cotton is minimal. Some growers may have experienced problems with excessive N carryover, but this usually is a result of gross over application of litter, sometimes in excess of 10 tons per acre. Some researchers have suggested that around 5% of the total N applied may be carried over to next year's crop. This is reasonable from observations with cotton and corn in Alabama. High rates of broiler litter would slightly increase soil organic matter and thus the reserve of N in the soil. But this reserve cannot be depended upon to reduce next year's N application. It is also difficult to detect with soil inorganic N analyses.

Yield Enhancement

Yield enhancement from the use of broiler litter appears to be related mainly to the N applied **(See Table 1.).** Although there is generally thought to be some yield enhancement related to the benefits of additional organic matter in the soil - increased moisture retention, improved water infiltration (less runoff), improved soil structure, and better root growth. Higher soil organic matter has been associated with higher cotton yields in Alabama's Old Rotation experiment. Organic amendments have also been shown to reduce the harmful effects of plant parasitic nematodes.

Negative Effects

These and other experiments in Alabama have shown absolutely **NO NEGATIVE EFFECTS** of using broiler litter on cotton when the litter is applied primarily based on its N content and the N recommended for the crop. Some potential, long-term effects that are often mentioned include the following:

- ***Nitrate leaching to groundwater.*** This could occur if greater than 3-4 tons per acre per year are applied to the same site for many years, and a shallow water table exists under permeable soils. This is an unlikely scenario in Alabama cotton fields.

- ***Phosphorus buildup to excessive levels.*** Phosphorus (P) will buildup in the soil. Excessive P won't affect cotton growth or yield, but it could be an environmental problem in nonpoint source water pollution. Again, this is likely to be a problem primarily with annual, long-term P applications. Soil testing can avoid this situation. Good soil management can prevent P runoff from cropland (Mullins and Hajek, 1997).

- ***Heavy metal buildup.*** Broiler litter may contain high levels of zinc (Zn) and copper (Cu), and these metals do build up in the soil. However, one ton of litter may contain only 1 pound of Zn and/or Cu. Often 3 pounds Zn per acre are recommended for corn. Therefore, excessive Zn and/or Cu is not likely to be a problem where broiler litter is used for its N value on cotton. Soil tests can identify fields where Zn and Cu have built up to near phytotoxic levels.

Weeds from broiler litter. Studies in Alabama and North Carolina have shown rather conclusively that weeds are not transported in fresh broiler litter. However, high rates of broiler litter can stimulate weed seed already present to germinate.

Conclusions

Broiler litter can be used effectively as a source of N for cotton. Total N is almost as effective as N from ammonium nitrate fertilizer. In 4 of 7 site-years research in Alabama, total N in broiler litter was as effective as the total N in ammonium nitrate in increasing seed cotton yields. In other years, more N as broiler litter was needed. However, rates as high as 4 tons per acre or 240 pounds N per acre as broiler litter had no negative effects on cotton yields. In some cases, the higher rates as broiler litter enhanced yields. Pix was effective in enhancing yields in only 1 of 7 site-years. This was at the TVS location in 1992 when yields averaged over 3 bales per acre. There is some residual N effect from high rates (4 tons/acre) of broiler litter. However, at lower, recommended rates, this residual effect is not high enough to reduce the recommended N for cotton. Effective rates of broiler litter would be 2-3 tons per acre or between 120 and 180 pounds total N per acre. This can be applied at planting. **(See Table 1.)**

Table 1. Effect of annual ammonium nitrate, broiler litter, and Pix® applications on cotton lint yields at Tennessee Valley Substation (TVS) in North Alabama on a Decatur silty clay loam and at E. V. Smith Research Center (EVS) in Central Alabama on a Norfolk f.s.l.

Nitrogen Source	N rate lb/acre	Location and Year						
		- - - - - - TVS - - - - - -			- - - - - - - - EVS - - - - - - - -			
		1990	1991	1992	1991	1992	1993	1994
		- - - - - - - - - - Pounds of lint per acre - - - - - - - - - -						
None	0	720	360	950	730	400	740	420
Ammonium nitrate	60	870	400	1570	920	800	820	820
Ammonium nitrate*	60	940	420	1600	940	810	840	850
Ammonium nitrate	120	960	480	1840	1010	980	840	1010
Ammonium nitrate*	120	950	460	1970	1110	1010	740	980
Broiler litter	120	960	470	1680	1030	740	770	800
Broiler litter	180	1000	480	1020	1050	800	890	810
Broiler litter	240	980	530	1860	1210	1010	730	850
Broiler litter*	120	850	480	1770	1050	730	760	880
Broiler litter*	180	900	480	1960	1230	940	850	820
Broiler litter*	240	1120	560	1860	1290	900	860	760
Mean		**930**	**460**	**1710**	**1050**	**830**	**800**	**820**
L.S.D. (P<.10)		180	90	170	190	140	ns	180

***Pix applied**; 60 pounds of N is approximately equivalent to 1 ton of broiler litter.

References

Bitzer, C.C., and J.T. Sims. 1988. Estimating the availability of nitrogen in poultry manure through laboratory and field studies. J. Environ. Qual. 17:47-54.

Castellanos, J.Z., and P.F. Pratt. 1981. Mineralization of manure nitrogen--correlation with laboratory indexes. Soil Sci. Soc. Am. J. 45:354-357.

Mitchell, C.C., and C.E. Browne. 1992. Plant nutrient availability in fresh and composted poultry wastes. Proc. 1992 Nat. Poultry Waste Management Symp. p. 391-395.

Mitchell, C.C., J.O. Donald, and J. Martin. 1989. The value and use of poultry waste as fertilizer. Ala. Coop. Ext. Serv. Cir. ANR-244. Auburn University, AL.

Predicting N Availability - A Research Footnote

*Predicting **N** availability from animal manures is elusive. Bitzer and Sims (1988), using a predicted available **N** in poultry litter of 80% of inorganic **N** and 60% of organic **N**, found values ranging from 54 to 118% of the predicted value. They concluded that while their predicted available **N** was ". . . reasonably successful, (it) consistently overestimated the amount of available **N** in the manures." Much of the available **N** was released during the first few weeks after application (Bitzer and Sims, 1988; Castellanos and Pratt, 1981). Others have reported **N** availability factors of 75% the first year (USDA, 1979) to near 50% (Mitchell and Browne, 1992). Nitrogen management for cotton is difficult. However, from a practical, crop management standpoint, these data suggest that defining a precise **N** availability index is not essential to managing broiler litter as a source of **N** for cotton.*

Source:

Mitchell, C.C., C.H. Burmester, and K.L. Edmisten. 1991. Cotton fertilization management in Alabama. Ala. Coop. Ext. Serv. Cir. ANR-619. Auburn University, AL.

Mitchell, C.C., C.H. Burmester, C.W. Wood, and K.L. Edmisten. 1992. Broiler litter on cotton: 1990 and 1991 test/demonstration results. New Tech. Demo. Rep. No. S-03-92. Ala. Coop. Ext. Serv., Auburn University, AL.

Mullins, G.L., and B.F. Hajek. 1997. Phosphorus accumulation and loss from Alabama soils receiving poultry litter. Ala. Agric. Exp. Stn. Bul. No. 631. Auburn University, AL.

USDA. 1979. Animal waste utilization on cropland and pastureland. Utilization Rep. no. 6. Washington, DC. Science and Education Admin.

Additional information about using poultry manures as fertilizer can be found at:

"The Value and Use of Poultry Manures as Fertilizer".

Return to Cotton Fertility: Week1

ALABAMA COOPERATIVE Extension SYSTEM

CIRCULAR ANR-244
(11/95)

ALABAMA A&M AND AUBURN UNIVERSITIES

THE VALUE AND USE OF POULTRY MANURES AS FERTILIZER

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Poultry manure, properly handled, is the most valuable of all manures produced by livestock. It has historically been used as a source of plant nutrients and as a soil amendment. However, in areas of intense poultry production, overfertilization of pasture land with poultry manure occurs. The result is suspected ground water and surface water problems as excess nutrients run off the land or leach into ground water supplies.

To obtain maximum economic value of plant nutrients in poultry manure and to protect our water supplies from excessive nutrient runoff or leaching, poultry manure should be applied to match nutrient needs of crops.

NUTRIENT ANALYSIS OF BROILER LITTER

Two basic types of poultry wastes are produced in Alabama: broiler litter and caged layer manure. Broiler litter, for the purposes of fertilization, includes all floor-type birds such as broilers, pullets, and floor layers. Bedding material such as wood shavings or peanut hulls is used to absorb liquids. Caged layer manure is usually free from litter material and generally has a higher moisture content. Both types of waste will contain feathers and some wasted feed.

Chemical analysis of either type of manure varies due to moisture, temperature (more N will be lost at higher temperatures), amount and kind of bedding, amount of soil picked up while a house is cleaned, number of batches consecutively reared, and conditions under which the manure was stored and handled prior to spreading. Alabama broiler litter is less variable than caged layer manure.

Between 0.5 and 0.7 pound of litter is produced per pound of market weight. Because broiler production has become more efficient in recent years, there is less waste produced per pound of market weight than 10 years ago when the value was around I pound of litter per pound of market weight. The decrease in waste per pound is due to drier litter (less than 20 percent moisture compared to more than 30 percent 10 years ago), improved feed conversion, and more birds on less bedding.

Layer manure is highly variable because each operation collects, stores, and handles manure differently. Nutrient content in broiler

Table 1. Average Nutrient Composition Of Alabama Broiler Litter On A Fresh Weight Basis.

	Weighted Mean[a]
Number of samples	207.0
Moisture, %	19.7
Primary Plant Nutrients	
Total N, %	3.10
P_2O_5, %	2.77
K_2O	2.04

litter and layer manure from different sources and surveys is reported in Tables 1 and 2.

Caged layer manure generally contains between 1 and 2 percent N on a fresh weight basis (4 to 7 percent on a dry weight basis) if collected at 1- to 3-week intervals. However, under high-rise houses where layer manure sometimes accumulates for long periods of time, some N is lost into the air as ammonia gas. At the same time, manure dries which increases concentration of all nutrients.

Moisture is the most important variable to consider when manure is spread by the ton. Manure will average 70 to 77 percent moisture when excreted. However, broiler litter dries under normal house conditions and will average about 20 percent moisture. Caged layer manure is much more variable depending upon the storage system. Because manures and litter are spread by the ton as they are removed from the house or from storage, analyses should be compared on a fresh weight basis.

Secondary Plant Nutrients	
Ca, %	1.79
Mg, %	0.38
S, %	0.34
Micronutrients	
Cu, ppm	332
Fe, ppm	1,950
Mn, ppm	277
Zn, ppm	252
B, ppm	55
Other Analysis	
As, ppm	281.0
Ash, %	18.8

[a] Weighted mean is calculated from four separate surveys conducted in Alabama from the mid-1980s through 1993. The surveys included a total of 207 samples.

Table 2. Nutrient Composition Of fresh, Caged Layer Manure.

	Pennsylvania [a] caged layers	Pennsylvania [b] caged layers	Alabama caged layers	North Carolina [c]		
				fresh	scraped	high rise
Moisture, %	60	50	70	--	--	--
Primary Plant Nutrients						
Total N, %	1.94	2.0	1.5	1.3	1.4	1.9
P_2O_5, %	2.85	2.0	1.3	1.1	1.6	2.8
K_2O, %	1.61	1.0	0.5	0.5	1.0	1.5
Secondary Plant Nutrients						
CA, %	6.15	3.50	--	--	2.10	4.30
MG, %	0.15	0.25	--	--	0.30	0.30
S, %	--	0.25	--	--	0.35	0.44
Micronutrients						
CU, ppm	--	15	--	--	18	22
Fe, ppm	--	450	--	--	260	900
Mn, ppm	--	150	--	--	135	260
Zn, ppm	--	150	--	--	160	185
B, ppm	--	20	--	--	25	23
Na, %		--			0.22	0.25

[a] Patterson, P.H., 1994. Estimating manure production based on nutrition and production: Laying hens. Proc. 1994, Poultry Waste Management Symp. pp. 90-96.

[b] Shipp, R. F., H. C. Jordan, W. W. Hinish, and D. B. Beegle. 1981. Spec. Cir. 274. The Pennsylvania State Univ. College of Agriculture, Extension Service. University Park, PA.

[c] Zublena, J. P., J. C. Barker, and T. A. Carter . 1993. Poultry manure as a fertilizer source. North Carolina Coop. Ext. Serv. Soil Facts. Raleigh, NC.

NUTRIENT AVAILABILITY

Poultry manure is managed primarily for its nitrogen (N) value. However, N availability from broiler litter is the most difficult of the three primary nutrients to predict. About one-third of the total N in broiler litter is in the ammonium form (NH_4-N) and the rest is in an organic form. The amount of N available for plant uptake is ammonium nitrogen plus the amount of organic nitrogen that mineralizes during the growing season.

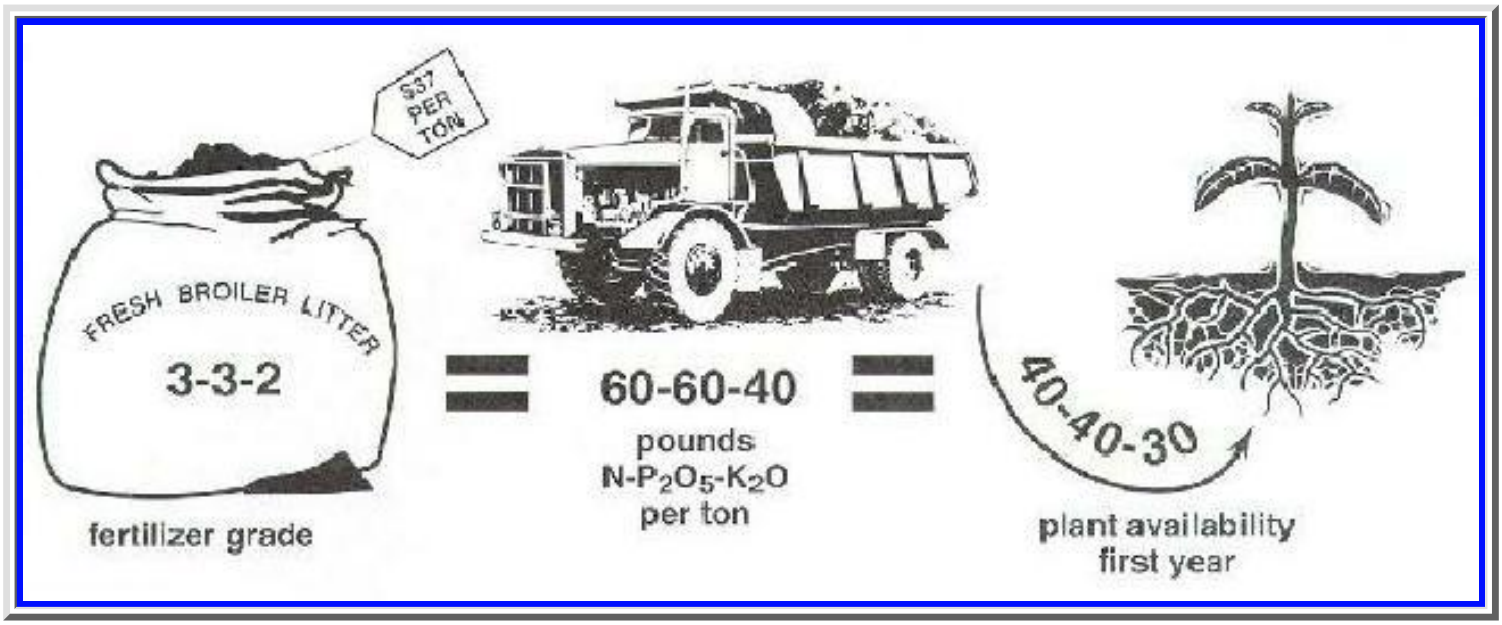
From **Table 1** , broiler litter has the following average nutrient content:

Fertilizer grade:	3- 3- 2 (N-P_2O_5-K_2O)
Total nutrients (lb./ton):	60-60-40
Available nutrients first season (lb./ton):	40-40-30

Ammonium N. The ammonium N fraction (NH_4-N) is subject to conversion to ammonia gas (NH_3) and atmospheric loss (volatilization). When manure has a strong ammonia odor or is spread on the surface of a soil and not incorporated, significant N will be lost to the air. Losses typically range from 15 to 50 percent of the ammonium fraction (5 to 20 percent of total N) when broiler litter is surface applied. If layer manure is spread as a liquid or slurry, as much as 75 percent of the ammonium N (one-fourth of total N) could be lost within 7 days after spreading when the weather is hot and dry and manure is not soil-incorporated. Of course, incorporation is not practical or even desirable in some situations such as pastures or hay fields, and ammonium N loss should be deducted from the total amount to be applied.

Organic N. The organic N fraction gradually becomes available for crop uptake as the manure decomposes (mineralizes). Mineralization rates can range from 40 to 90 percent depending on environmental conditions. For broiler litter in Alabama, assume that 60 percent of the organic N may be released during the first year following application. Therefore, around 70 percent of the total N in broiler litter will be available to the crop the first year after application.

Phosphorus (P) And Potassium (K). The P and K fractions are considered to be about 75 percent as effective as commercial fertilizers during the first year of application. If litter is applied at rates that will supply all N needed by the crop, P and K applications greater than those needed by the crop may occur. Under frequent manure applications, P will build up in soils to extremely high levels. Potassium may also build up unless large quantities of hay or forage are removed.



FERTILIZER VALUE OF BROILER LITTER

Estimated value per pound of nutrient is based upon the 1995 retail cost for ammonium nitrate (34-0-0), liquid N solution (32-0-0), concentrated superphosphate (0-46-0), and muriate of potash (0-0-60):

N..... $0.29/pound
$P_2 0_5$..... 0.23/pound
$K_2 0$..... 0.15/pound

Using an average fertilizer grade of 3-3-2 (Table 1), a reasonable estimate of the value of broiler litter would be about $37 per ton. if only readily available nutrients are considered, then the value would be around $25 per ton.

LAND APPLICATION

When applying poultry manure to cropland, pastureland, and hayfields, consider the following:

- Determine the nutrients in the manure prior to spreading. An analysis by a commercial laboratory determines moisture, total N, and other plant nutrients and allows the farmer to calculate the value of the manure and how much to apply. if a chemical analysis is not made, average nutrient contents of broiler litter can be used such as 60-60-40 pounds total N-P_2O_5-K_2 O per ton or 40-40-30 pounds of available nutrients per ton. If litter is analyzed for available nutrients, keep in mind that stored litter can change over time unless protected.
- Credit previous manure applications. If more than 4 tons per acre of broiler litter has been applied during the past 2 years, residual soil organic N should be considered. About 5 pounds of N per ton of litter applied last year will become available to this year's crop. This amount needs to be subtracted from the total N recommended for the crop.
- Soil test for residual nutrients. Soil testing provides the best estimate of residual P and K in the soil and other soil amendments (such as lime) that should be applied for optimum yields and efficient nutrient use. If soil test P is rated very high (VH) or extremely high (EH), consider using a commercial fertilizer that does not contain P, such as 15-0-15 or ammonium nitrate (34-0-0). Continued application of manures, especially broiler litter, will increase soil P to the point that surface water enrichment with P could result. If soil test P is not VH or EH, apply litter or manure based upon recommended N rate for the crop to be grown. The N recommendation is given on the soil test report. Exceeding recommended rates for available nutrients by more than 50 percent could result in excessive N leaching in some soils or potential surface runoff into streams.
- Calculate litter or manure needs based upon N availability. For example, 60 pounds of N per acre is recommended for fescue pasture in the fall and again in the spring. If 1 ton of litter contains 40 pounds of available N, then 1.5 tons should be applied per acre in the fall and again in the spring.
- Check application rates. Check the actual rate that is applied by calibrating spreading equipment. A drop cloth to collect and weigh the litter that is spread on the field is a quick way to estimate application rate (See Circular ANR-889 "Calibrating Poultry Litter Spreaders").
- Apply litter at the right time. Timing of application should correspond to the time of year when the crop can use the nutrients. Applying litter when there is no actively growing crop or at a time of the year when the crop is dormant is inefficient use of plant nutrients and could result in surface and ground water contamination.

ADDITIONAL FACTS ABOUT USING POULTRY MANURE

Broiler Litter Storage. Broiler litter is most valuable immediately after it is removed from the house. The N in the litter can be preserved if it is stored in an enclosed structure (dry stack barn) or in a deep pile that is covered (See Circular ANR-839, "Broiler Litter Storage"). **Never store litter outside and exposed to the weather!** Broiler litter should be handled like commercial fertilizers. Rain can leach valuable nutrients into surface waters. Manure stored outside and exposed to the weather will decompose rapidly. An ashy-gray appearance indicates a loss of nutrient value.

Composted Broiler Litter. When broiler litter is exposed to air and moisture, the ammonium N component is converted to organic N. Therefore, N in composted litter or litter that has been exposed to the weather for several months is less available to the crop. The moisture content of composted litter is generally around 40 percent compared to 20 percent in fresh litter. Composting also reduces its value. Composted litter may have a fertilizer grade of 1.5-3-1 compared to a 3-3-2 for fresh litter.

Poultry Mortality Composts. Composted dead birds from a broiler operation have about the same nutrient concentration as fresh litter on a fresh weight basis. A survey of 30 composters in Alabama found an average moisture of 36 percent. On a fresh weight basis, the average fertilizer grade of the secondary compost was 2.4-2.6-1.6 (48-52-32 pounds N-P_2 O_5-K_2O per ton).

Ammonia Odors. To conserve N in poultry manure and to reduce ammonia odor and associated N loss, superphosphate can be applied at the rate of 100 pounds per ton of manure in the house. The phosphate will trap the ammonia as ammonium phosphate. However, the increased P in the litter may not be needed by the crop.

Hydrated Lime. Hydrated lime (calcium hydroxide) will help dry out litter, reduce fly problems, and maintain good litter condition. However, it will also increase ammonia volatilization and N loss. Do not use it when the ammonia level in the house is high. Use lime at the rate of 50 pounds per 1,000 square feet of floor space. **Never apply agricultural lime to poultry houses!**

Litter Disposal. Where excess quantities of manure must be disposed on the land chose a cropping system to maximize N uptake. Row crops are poor users of soil N because of a limited root system. Corn or cotton may take up only 50 to 60 percent of the N applied. Grasses, such as hybrid bermudagrass and bahiagrass, produce large amounts of dry matter and are efficient N users. As much as 90 percent of the applied N could be recovered by a good bermudagrass sod. Cool season grasses such as fescue and ryegrass are not as efficient because most of their growth is in the early spring. Harvest excess forage frequently to remove N from the land. These practices will minimize potential surface and ground water contamination from excess N applied in manure.

Liming Value Of Poultry Manures And Broiler Litter. Because layers are fed ground limestone, the manure has some liming value. Even broiler litter may increase the soil pH slightly. However, layer manure and broiler litter should be applied for its nutrient value. Monitor soil pH with routine soil testing and apply additional agricultural lime if needed.

Return to Cotton Fertility Training Schedule

CLEMSON EXTENSION

COTTON FERTILITY
Internet Inservice Training

WEEK 1:
Nitrogen Fertilization

At the end of this week, you should know:

1. **The forms and amounts of nitrogen required for optimum cotton production.**
2. **Optimum timing for nitrogen applications.**
3. **Effects of Pix applications on nitrogen response.**
4. **Effects of previous crops on nitrogen requirements.**
5. **The benefits of broiler litter for cotton.**
6. **Guidelines for applying broiler litter to avoid cotton growth problems.**
7. **How to use the petiole nitrate monitoring program.**
8. **Effects of foliar boron applications along with foliar nitrogen applications.**

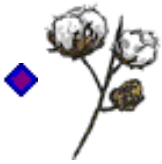
Nitrogen Fertilization: General Information

Use of Poultry Litter

Petiole Nitrate Monitoring

Foliar Boron

[Return to Cotton Fertility Training Schedule]



Attendance: