Nutrient Availability in Wheat During Growing Season Comparing Poultry Litter and Inorganic Fertilizer

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Major Project/Report submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Online Master of Agriculture and Life Sciences

In

Plant Science and Pest Management

Committee

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Abstract

Winter wheat production in North Carolina is continuing to expand. Commercial fertilizer costs are also continuing to rise and growers are looking for other options for plant nutrients. Poultry litter is a common fertilizer source that has been used in the past and is more popular now due to being a cheaper alternative to inorganic fertilizer. However, not all poultry litter is created equal in terms of nutrient content and in order to know what is in the litter, manure analysis must be performed. It is also unclear how much the litter breaks down within the first cropping season and how much of the nutrients are available for plant uptake. Thus, a study was performed to evaluate the nutrient availability of poultry litter compared to inorganic fertilizer during the 2021-2022 wheat growing season. The study took place in Lawndale, North Carolina on a field farmed by Toluca Grain and Hay. During the growing season, tissue samples were collected from each treatment (1- nonfertilized control, 2- poultry litter fertilized, and 3- inorganic fertilizer) and analyzed for N, P, and K nutrient levels. At harvest, each plot sample was weighed in a weigh wagon, and a smaller sample from each plot was tested using a certified scale for test weight and moisture content. There were no significant differences in yield and test weight between the poultry litter and inorganic fertilizer treatments. However, the poultry litter tissue samples and final soil samples showed higher levels of phosphorus and potassium than the other treatments. Poultry litter proved to be an effective alternative fertilizer to inorganic fertilizer at a lower cost.

Acknowledgements

Thank you to Southern States in Waco, NC for the donation of the inorganic fertilizer for the study. Also a big thank you to Toluca Grain and Hay for the land and labor for the study.

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Introduction

In 2021, the USDA reported that North Carolina planted 450,000 acres of winter wheat (*Triticum aestivum* L.). Since that acreage assessment, growers have faced the cost of fertilizer doubling. Fortunately, over this same time span, the price of wheat was increasing, however the input prices to grow wheat have increased substantially. This issue made farmers second guess whether they should grow wheat or just use enough fertilizer to get an average yield to break even. Thankfully, there are alternative fertilizer options rather than just using expensive conventional inorganic fertilizers. Poultry litter is a commonly used fertilizer in North Carolina and has been a cheaper alternative to inorganic fertilizer in wheat production.

Poultry litter is a great alternative fertilizer because not only does it provide nutrients, it builds organic matter as well. Poultry litter provides the necessary macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) along with calcium, magnesium, sulfur, and other micronutrients (Zhang et al., 2013). Litter from broiler houses is most sought after due to having higher nutrient levels compared to laying houses. However, there are a few drawbacks to using litter over inorganic fertilizer. Most notably, there is a high degree of variability in nutrient levels and litter decomposition. Also, nutrient release during the cropping season varies by litter source and environment. Fortunately, litter and manure can be sent off for analyses to determine nutrient presence and levels within the litter, thus determining the rate that should be applied to a field. As for nutrient breakdown and availability, that is a little more tricky as it is said that nitrogen availability from the litter can range from 30-80% during the year of application (Zhang et al., 2013). It is also a common conception that using litter as a fertilizer source introduces weed seed to the field but this was not evident in this study.

Farmers use poultry litter on their crops expecting approximately 50% breakdown of the litter during the first cropping season and the remainder for a second growing season. Although it takes longer for litter to break down compared to inorganic fertilizer, growers may receive greater benefits from using litter and having extra nutrients in the ground that may be available for future crops versus inorganic fertilizers that only last for a single cropping season. Comparing poultry litter and inorganic fertilizer on wheat during the same growing season can be accomplished through tissue sampling to analyze how nutrient availability and uptake differs between the two fertilization sources. This information is beneficial for growers that would rather use a cheaper alternative to inorganic fertilizer and show that yields will not be decreased by utilizing litter. This study was conducted to see how wheat responded to poultry litter and conventional inorganic fertilizers and how readily available nutrients from the treatments were to the wheat crop. This study took place in Lawndale, North Carolina near Toluca Grain and Hay.

Objectives

The purpose and objective of this project was to determine if nutrient availability from poultry litter during the wheat growing season was better or equal to the availability of inorganic fertilizer. These two treatments were evaluated during the 2021-2022 wheat growing season in Lawndale, NC. During the study, soil samples and tissue samples were collected and evaluated with yield being assessed at the conclusion.

Literature Review

The primary macronutrients for plants are nitrogen, phosphorus and potassium (N, P, K) however, these nutrients are not the only ones that play a vital role in plant growth and health.

There are also secondary macronutrients such as calcium, magnesium, and sulfur and other micronutrients. Macronutrients are nutrients that are required in larger amounts while micronutrients are only required in small amounts. When looking at fertilizer options, N, P, and K are the most important and reported components and are what many farmers concentrate on.

Of the macronutrients, nitrogen is required in the greatest amount by plants, especially wheat. All of the wheat plant's nitrogen needs to be applied by growth stage 30/ Feekes 4-5. At this stage, wheat starts erect growth after tillers are formed. The plant switches from producing tillers and growing vegetatively and begins reproductive growth.

Plants can absorb nitrogen in different forms including nitrate, ammonia, or urea (Kulcheski et al., 2015). Nitrogen comprises about 1.5-2.0% of plant matter (Tripathi et al., 2014). Nitrogen deficiencies show up first in older plant tissue since it is mobile within plants. The plants will appear to be yellow in color, stunted, and develop slowly. Poultry litter is a great source of nitrogen, phosphorus, and potassium, but not all litter is created equally, thus, it is important to test the litter to analyze the nutrient content.

Phosphorus is also an important macronutrient for plants. Phosphorus plays a major role in seed germination and early plant growth as well as stimulating growth of wheat kernels, and has a role in determining when the plant reaches maturity (Post et al., 2021). Phosphorus deficiency can be seen in plants that have stunted growth and leaves appear to be purple along the leaf margins and tissue. According to the North Carolina Small Grain Production Guide 2021, most North Carolina soils are usually high or very high in phosphorus so this is usually not a problem in this area. Phosphorus deficiencies generally appear when wheat plants are under adverse conditions such as severely cold temperatures and extremely wet soil.

Last but not least, potassium contributes less to wheat plant growth and more to grain quality, including test weight. The test weight (lbs/bu) is important in determining whether wheat will be milling or feed quality. Potassium also affects oil content, prevents lodging, and plays a role in drought and disease tolerance (Post et al., 2021). Lodging is when the stem of the plant bends near the ground and makes harvesting more difficult. Lodging is often influenced by weather conditions such as heavy wind, rain, and hail. Deficiency symptoms of potassium include stunted growth and premature lodging in the plant. Potassium levels are not commonly deficient in clay soils, however it is more prevalently observed to be limiting in sandy soils.

Although poultry litter has been used in south-west North Carolina, little research has been conducted to determine nutrient decomposition and subsequent plant uptake during the first wheat cropping season. Most farmers apply their poultry litter in the fall right after planting wheat or late winter/early spring before the wheat comes out of dormancy. Poultry litter is usually applied at a rate of 2-4 tons per acre depending on the estimate of nutrients available in the litter. The objective of this project was to determine if nutrient availability of poultry litter during the wheat growing season was better or equal to the availability of inorganic fertilizer.

Materials and Methods

Projected Audience:

The targeted audiences for this research project are grain producers in the region, as well as fellow extension and industry personnel. The expected outcome is to compare poultry litter, a cheaper alternative fertilizer option, to inorganic fertilizer on wheat.

Research Methodology:

This research project examined 3 fertilizer treatments on 1 wheat cultivar during the 2021-2022 growing season. This project was executed with the help of Toluca Grain and Hay located in Lawndale (Toluca), North Carolina. The wheat was planted on November 6, 2021 and harvested on June 18, 2022. The wheat was sown using a 15-foot John Deere 1590 seed drill at a depth of 1 inch and seeding rate of 120 pounds per acre. Information about the FS855 cultivar that was planted in this study is listed in Figure 1.

The trial plot was located on the upper end (approximately 60 feet from the edge) of a 23.87 acre commercial wheat field (Fig. 2). This field has a long history of no-till small grain and soybean rotation as well as previous applications of poultry litter and inorganic fertilizers depending on the year. There were 3 replications of the treatments: 1) non-fertilized control, 2) poultry litter fertilized, and 3) conventional inorganic fertilizer. The control and poultry litter plots measured 30 feet wide and 200 feet long, corresponding to the litter truck spreading width (30 feet). The inorganic fertilizer plots were 80 feet wide and 200 feet long to accommodate the fertilizer truck spreading width. Each treatment was separated by a 5-foot buffer.

A baseline soil sample was collected on November 3, 2021 prior to planting to determine fertilizer recommendations (based on 80 bu. wheat production): as well as to evaluate the nutrient levels in the field before treatments were added. After the wheat had germinated and initiated fall tillers, but before spring growth had begun, the first tissue samples were collected on February 1, 2022. This was the baseline tissue sample. All of the above ground portion of the plant was cut and placed into a bag, the amount was about as big as a softball, 3.8 inches in diameter. Also on February 1, 2022, the poultry litter and inorganic fertilizer was applied. The control group did not receive nutrient additions at this time. The poultry litter was spread at a rate

of 3 tons per acre. The litter composition analysis is shown in Figure 3 (combination of sample 003 and 004). The inorganic fertilizer blend was applied at 559 pounds per acre and compositional analysis is shown in Figure 4.

A top dress fertilizer application was made to the whole field, including the control treatment plots on February 12, 2022. This consisted of a dry granular application of 60 units of urea and 15 units of sulfur per acre. On March 5, 2022 an application of 6 fl oz/A Aproach Prima fungicide (cyproconazole + picoxystrobin), 0.75 oz Quelex herbicide (halauxifen-methyl + florasulam) with 2 pints of surfactant to 100 gallons of water was applied. The second collection of tissue samples occurred on March 7, 2022. Each plot was sampled by cutting approximately 40 plants in each plot, taking the entire above ground portion. At this point the wheat was in stage Feekes 5/tillering.

The final tissue samples were collected on April 14, 2022 during the flag leaf/Feekes 8 stage of wheat growth. Approximately 30-40 flag leaves including ⅔ of the plant/stems were collected in each plot. The wheat was harvested on June 18, 2022 using a John Deere 9550 combine with a 18 foot header. One pass through the middle of each plot was made, this area was calculated to be 0.08 acres. The harvested wheat was placed into a weigh wagon where each sample was weighed. A small portion of the samples were collected out of the weigh wagon from each plot and taken to a local grain elevator where the moisture and test weight was recorded using a certified grain scale. Soil samples were collected for each treatment (replications of the same treatments combined) after the harvest on June 21, 2022 to determine what nutrients remained in the soil for the next crop according to fertilizer treatment. Data was entered into Agricultural Research Manager version 2022.2 (Gylling Data Management,

Brookings, SD), analyzed using analysis of variance with mean separations determined using Fisher's LSD ($P \leq 0.05$).

FS 855

NEW

RM | MEDIUM-EARLY

InSPIRE WHEAT

KEY POINTS

» Outstanding yield potential across all soil types
» Very good Head Scab and Stripe Rust tolerance
» Good test weight and standability

AGRONOMICS

YIELD POTENTIAL	1.5
STANDABILITY	2.0
TEST WEIGHT	2.0
WINTERHARDINESS	2.0

DISEASE RESISTANCE

FUSARIUM HEAD SCAB	1.5
SEPTORIA LEAF BLOTCH	2.0
SEPTORIA GLUME BLOTCH	2.0
POWDERY MILDEW	2.0
STRIPE RUST	2.0
LEAF RUST	2.0
STEM RUST	2.0
BARLEY YELLOW DWARF VIRUS	2.0
SPINDLE STREAK MOSAIC VIRUS	NA
SOIL-BORNE MOSAIC VIRUS	2.0

Rating Scale: 1 - 5, 1 = Excellent, 5 = Poor, NA = Not Available

CHARACTERISTICS

Maturity	Medium-Early
Plant Height	Medium Tall
Head Type	Bearded
Kernel Size	Average
Seeding Rates	Medium

AGRONOMICS

Yield Potential	1.5
Standability	2.0
Test Weight	2.0
Winterhardiness	2.0

PEST/DISEASE RESISTANCE

Hessian Fly	Moderate Resistance
Fusarium Head Scab	1.5
Septoria Leaf Blotch	2.0
Septoria Glume Blotch	2.0
Powdery Mildew	2.0
Stripe Rust	2.0
Leaf Rust	2.0
Stem Rust	2.0
Barley Yellow Dwarf Virus	2.0
Spindle Streak Mosaic Virus	NA
Soil-Borne Mosaic Virus	2.0

Rating Scale: 1 - 5, 1 = Excellent, 5 = Poor, NA = Not Available

Figure 1. Information on the FS855 wheat cultivar used in this study.

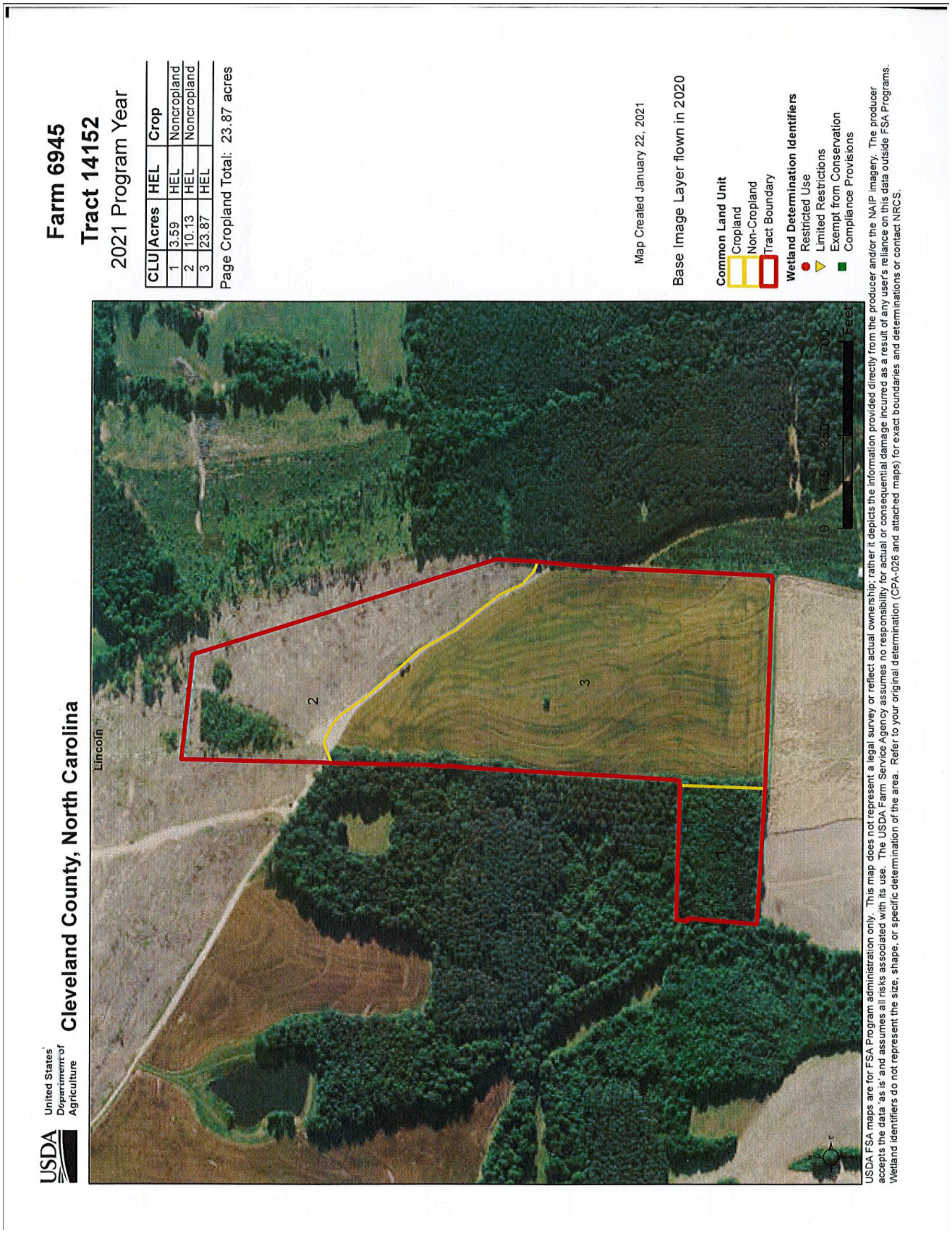

Figure 2. USDA print out field where project was conducted (3).

Manure Analysis

Waters Agricultural Laboratories, Inc

364 W. Park Drive | Warsaw, NC 28398- | Phone (910) 293-2108

"Improving Growth... With Science"

HEATHER SCHRONCE 415 S HWY 18 LAWNDALE, NC 28090-	**Grower:** HEATHER SCHRONCE **Sample Number:** 003 **Lab Number:** 10185MS **Received:** 11/29/2021 **Processed:** 11/30/2021
Type: Poultry House Litter-Broiler	**Application Method:** Broadcast

Manure/Sludge Analysis

Analyte	Percent (%) (As-Is Basis)	Percent (%) (Dry Basis)	Pounds per Ton (As-Is Basis)	Estimate of Nutrients Available (lbs/Ton)
Nitrogen-Total	**3.57**	4.802	71.4	35.7
P2O5-Total	**3.31**	4.452	66.2	66.2
K2O-Total	**3.0**	4.035	60	60
Calcium	**2.57**	3.457	51.4	51.4
Magnesium	**0.69**	0.928	13.8	13.8
Sulfur	**0.73**	0.982	14.6	14.6
Boron	**0.06**	0.081	1.2	1.2
Zinc	**0.05**	0.067	1	1
Manganese	**0.06**	0.081	1.2	1.2
Iron	**0.13**	0.175	2.6	2.6
Copper	**0.07**	0.094	1.4	1.4
Sodium	**0.82**	1.103	16.4	16.4
Aluminum	**0.22**	0.296	4.4	4.4

Additional Analysis

Analyte	Result	Units
Moisture	**25.65**	%

Results Reported On: Wet (As Received) Basis

Manure Analysis

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"Improving Growth... With Science"

HEATHER SCHRONCE 415 S HWY 18 LAWNDALE, NC 28090-	**Grower:** HEATHER SCHRONCE **Sample Number:** 004 **Lab Number:** 10186MS **Received:** 11/29/2021 **Processed:** 11/30/2021
Type: Poultry House Litter-Broiler	**Application Method:** Broadcast

Manure/Sludge Analysis

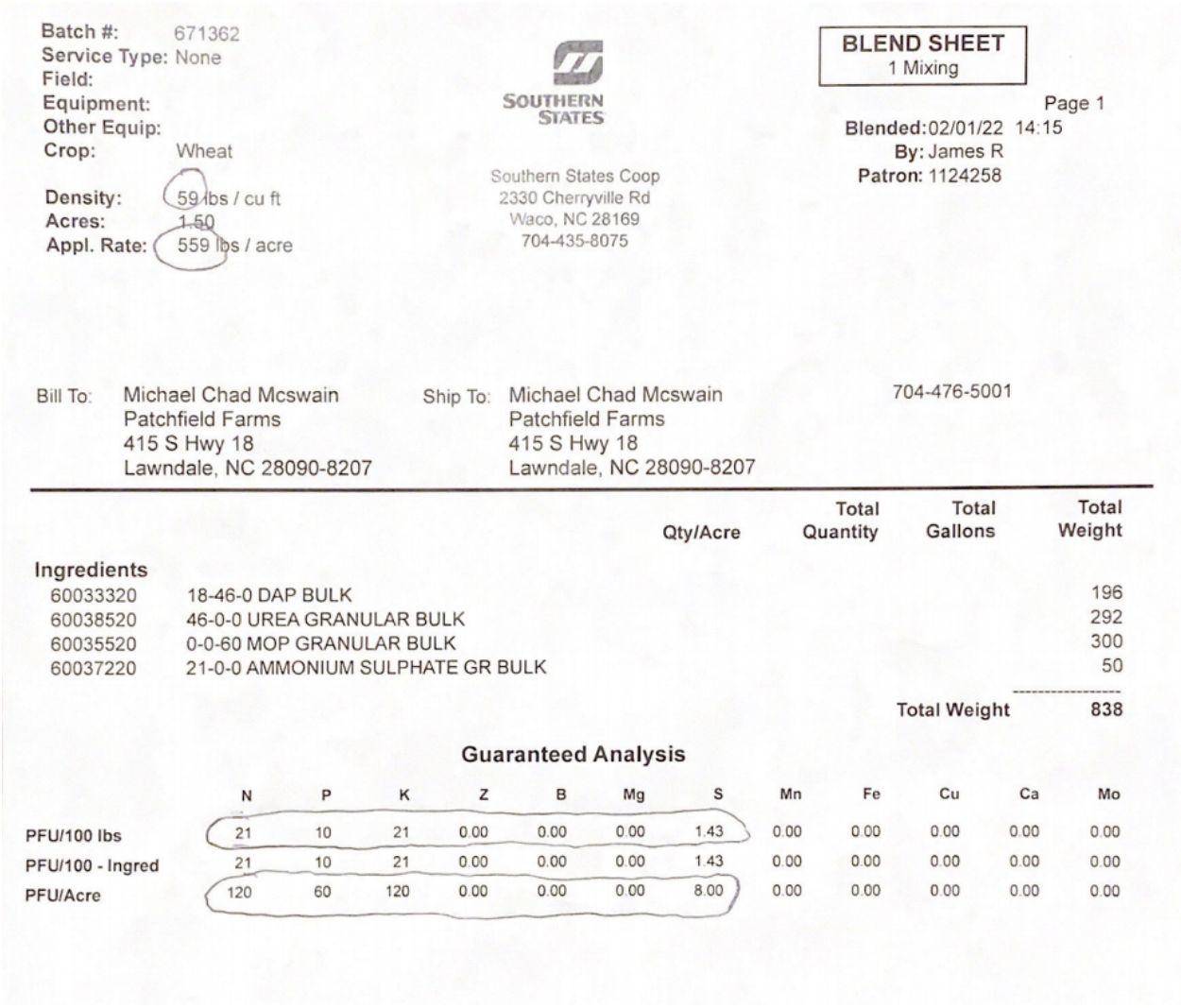
Analyte	Percent (%) (As-Is Basis)	Percent (%) (Dry Basis)	Pounds per Ton (As-Is Basis)	Estimate of Nutrients Available (lbs/Ton)
Nitrogen-Total	**4.06**	5.192	81.2	40.6
P2O5-Total	**3.17**	4.054	63.4	63.4
K2O-Total	**3.33**	4.258	66.6	66.6
Calcium	**2.43**	3.107	48.6	48.6
Magnesium	**0.61**	0.78	12.2	12.2
Sulfur	**1.08**	1.381	21.6	21.6
Boron	**0.07**	0.09	1.4	1.4
Zinc	**0.05**	0.064	1	1
Manganese	**0.06**	0.077	1.2	1.2
Iron	**0.07**	0.09	1.4	1.4
Copper	**0.06**	0.077	1.2	1.2
Sodium	**0.80**	1.023	16	16
Aluminum	**0.22**	0.281	4.4	4.4

Additional Analysis

Analyte	Result	Units
Moisture	**21.8**	%

Results Reported On: Wet (As Received) Basis

Figure 3. Poultry litter nutrient analysis for what was used in this study.



Batch #: 671362
Service Type: None
Field:
Equipment:
Other Equip:
Crop: Wheat

Density: 59 lbs / cu ft
Acres: 1.50
Appl. Rate: 559 lbs / acre

SOUTHERN STATES

Southern States Coop
2330 Cherryville Rd
Waco, NC 28169
704-435-8075

BLEND SHEET
1 Mixing

Page 1
Blended: 02/01/22 14:15
By: James R
Patron: 1124258

Bill To: Michael Chad Mcswain
Patchfield Farms
415 S Hwy 18
Lawndale, NC 28090-8207

Ship To: Michael Chad Mcswain
Patchfield Farms
415 S Hwy 18
Lawndale, NC 28090-8207

704-476-5001

		Qty/Acre	Total Quantity	Total Gallons	Total Weight
Ingredients					
60033320	18-46-0 DAP BULK				196
60038520	46-0-0 UREA GRANULAR BULK				292
60035520	0-0-60 MOP GRANULAR BULK				300
60037220	21-0-0 AMMONIUM SULPHATE GR BULK				50
				Total Weight	**838**

Guaranteed Analysis

	N	P	K	Z	B	Mg	S	Mn	Fe	Cu	Ca	Mo
PFU/100 lbs	21	10	21	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00
PFU/100 - Ingred	21	10	21	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00
PFU/Acre	120	60	120	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00

Figure 4. Inorganic fertilizer blend nutrient analysis for what was used in this study.

Figure 5A and 5B. Wheat March 3, 2022 in control treatment plot.

Figure 6. Tissue sample collection on April 13, 2022.

Figure 7. Poultry litter (red) and inorganic fertilizer (blue) sections of this study April 13, 2022.

Figure 8A and 8B. Control treatment of wheat plot May 14, 2022.

Figure 9. Wheat plot on June 13, 2022 just prior to harvest.

Figure 10. Wheat harvest showing weigh wagon and combine used to evaluate yield on June 18, 2022

Figure 11. Samples collected for test weight and moisture measurements at harvest on June 18, 2022.

Results and Discussion

Crop yield and quality is what most farmers care about and there was no statistical difference between the treatments regarding yield and moisture content, but there was a small difference in test weight with the inorganic fertilizer treatment being significantly lower than the other treatments (Figure 12 and 13). One factor that could have caused this was a higher lodging rate in the inorganic fertilizer than the other treatments (data not shown). This lodging could potentially be from the wheat being further developed during growth (not physically noticed) and being damaged more during a late frost in April. This lodging is also hypothesized to have caused the lower test weight in this treatment. The control treatment had higher yield than expected. This could be because the control plots were physically placed between the other treatments which could have resulted in runoff of nutrients into the control plot even with the 5-foot buffer between plots. More likely, however, is that the history of litter application and frequency of soybean crops in the field resulted in significant mineralizable N.

The first tissue samples (tillering nutrients, Figure 14) indicate significant variability among the treatment plots. Nitrogen content within leaves was higher in inorganic fertilizer plots than the poultry litter and the control treatment. Phosphorus and potassium levels were relatively higher in the litter treatment samples over the control and inorganic fertilizer treatments. Examining the flag leaf tissue samples (Fig. 15), the litter treatment samples seem to have the highest overall concentrations. Nitrogen content was lower in the control group as expected but not significantly different between the litter and inorganic fertilizer plots. The litter treatment was relatively higher once again in phosphorus and potassium levels compared to both the control and inorganic fertilizer treatments.

Soil samples after the plots were harvested indicated higher recommendations for nutrients in the control treatment plots and the inorganic fertilizer plots regarding phosphorus and potassium (Fig. 16). There was no recommendation for phosphorus to the land to which poultry litter was applied.

Treatment/plot #	Weight from weigh wagon (lbs)	Test Weight (lb/bu)	Moisture (%)	Yield Calculations (bu/ac)
001 Control	388	57.3	10.6	81.9
002 Litter	460	57.2	10.4	97.3
003 Fertilizer	428	54.6	9.6	94.8
004 Control	464	56.7	10.5	99
005 Litter	460	56.7	10.3	98.2
006 Fertilizer	424	55.3	10.3	92.8
007 Control	274	56.5	10.8	58.7
008 Litter	454	57.3	10.5	95.9
009 Fertilizer	380	53.7	10.1	85.6

Figure 12. Yield, weigh, test weight, and moisture results

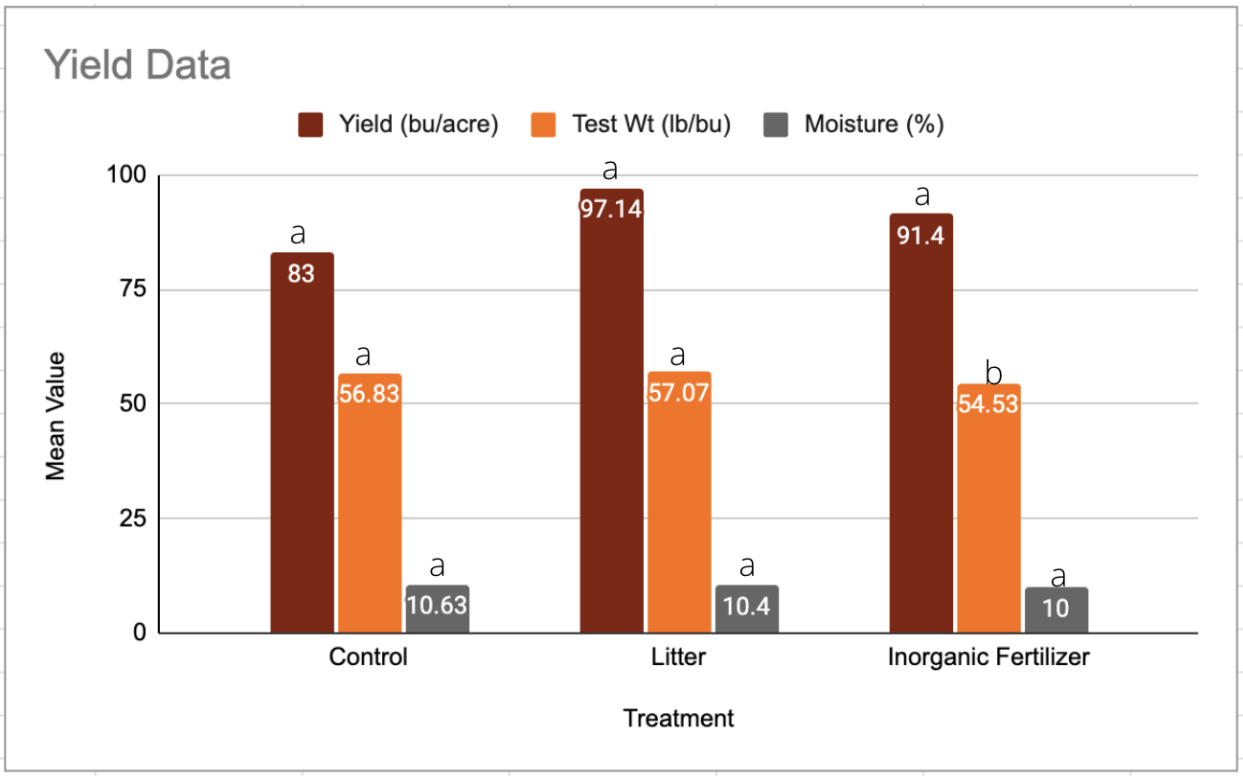


Figure 13. Yield data graph (similar letters do not indicate a significant difference at p=0.05)

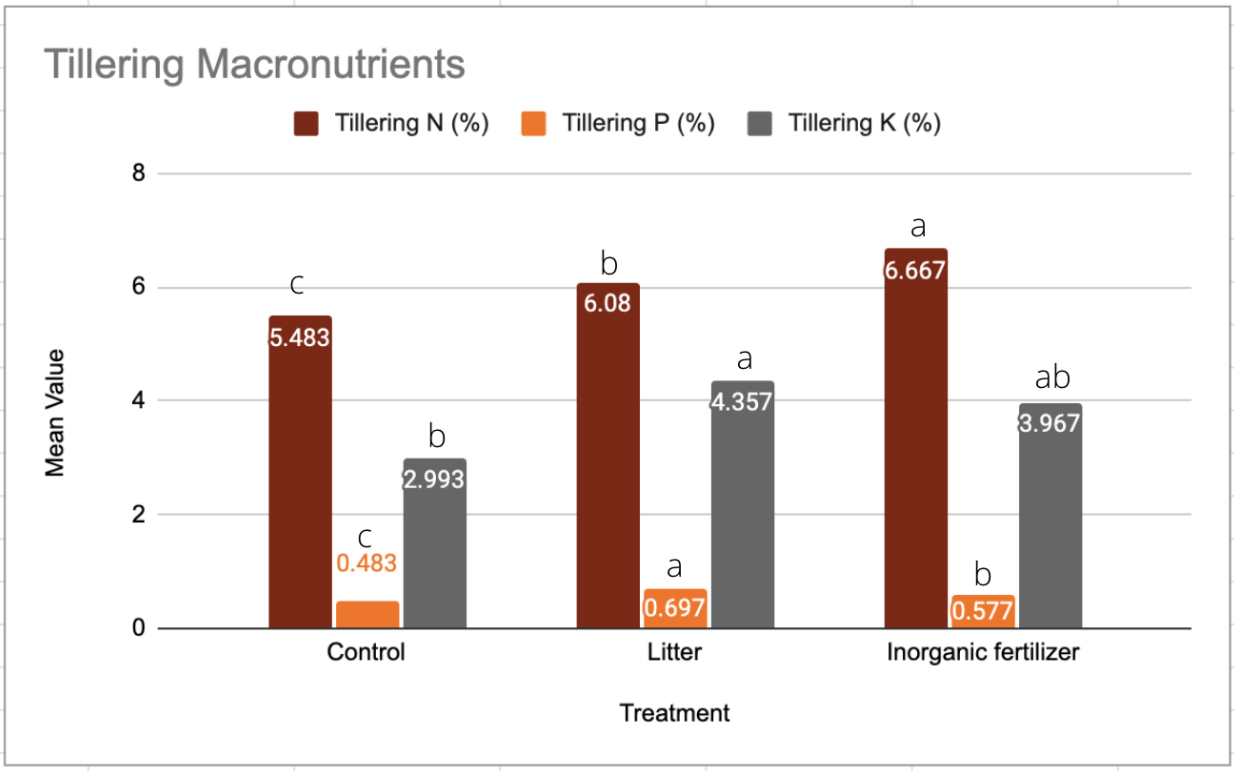


Figure 14. Tillering sample results (similar letters do not indicate a significant difference at p=0.05)

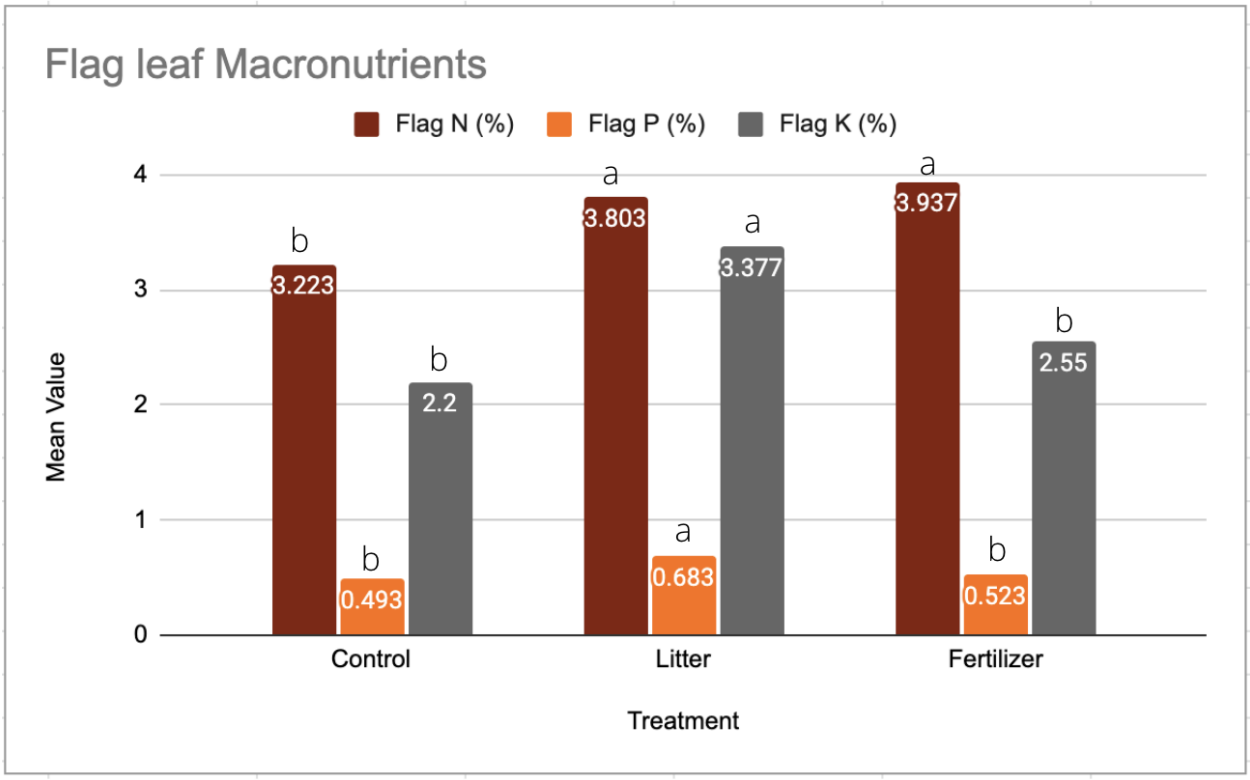
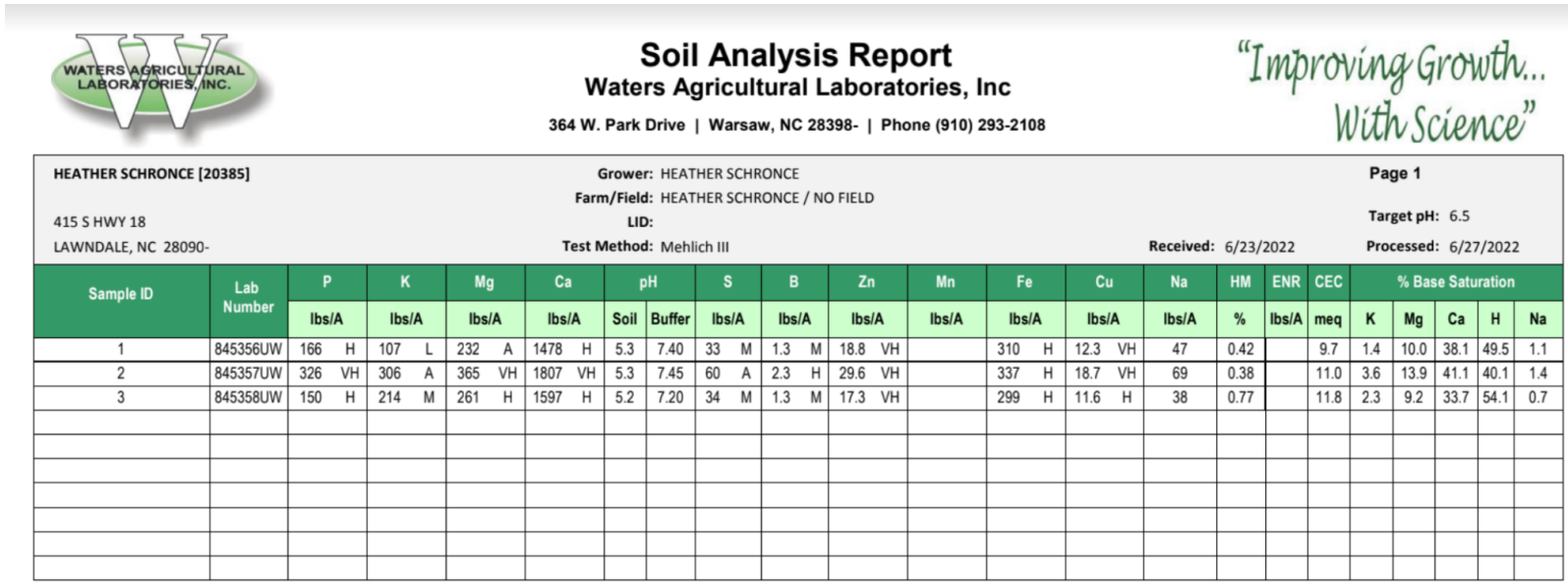


Figure 15. Flag leaf sample results (similar letters do not indicate a significant difference at p=0.05)



Soil Analysis Report

Waters Agricultural Laboratories, Inc

364 W. Park Drive | Warsaw, NC 28398- | Phone (910) 293-2108

"Improving Growth... With Science"

HEATHER SCHRONCE [20385]

415 S HWY 18

LAWNDALE, NC 28090-

Grower: HEATHER SCHRONCE

Farm/Field: HEATHER SCHRONCE / NO FIELD

LID:

Test Method: Mehlich III

Page 1

Target pH: 6.5

Received: 6/23/2022

Processed: 6/27/2022

Sample ID	Lab Number	P	K	Mg	Ca	pH		S	B	Zn	Mn	Fe	Cu	Na	HM	ENR	CEC	% Base Saturation				
		lbs/A	lbs/A	lbs/A	lbs/A	Soil	Buffer	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	lbs/A	%	lbs/A	meq	K	Mg	Ca	H	Na
1	845356UW	166 H	107 L	232 A	1478 H	5.3	7.40	33 M	1.3 M	18.8 VH		310 H	12.3 VH	47	0.42		9.7	1.4	10.0	38.1	49.5	1.1
2	845357UW	326 VH	306 A	365 VH	1807 VH	5.3	7.45	60 A	2.3 H	29.6 VH		337 H	18.7 VH	69	0.38		11.0	3.6	13.9	41.1	40.1	1.4
3	845358UW	150 H	214 M	261 H	1597 H	5.2	7.20	34 M	1.3 M	17.3 VH		299 H	11.6 H	38	0.77		11.8	2.3	9.2	33.7	54.1	0.7

Report values represent available plant nutrients in the soil. Rating Codes: L (Low), M (Medium), A (Adequate), H (High), VH (Very High)

Abbreviations: ENR (Estimated Nitrogen Release), C.E.C. (Cation Exchange Capacity), OM (Organic Matter)

Soil Fertility Recommendations (lbs/A)

Sample ID	Crop	Yield	Lime	Gypsum	N Nitrogen	P Phosphate	K Potash	Mg Magnesium	S Sulfur	B Boron	Zn Zinc	Mn Manganese	Fe Iron	Cu Copper
			Tons/Acre											
1	WHEAT	80 BUSHELS	2.7		120	* 40	130		7					
2	WHEAT	80 BUSHELS	2.5		120		* 70							
3	WHEAT	80 BUSHELS	3.7		120	* 40	* 80		6					

Explanation of Symbols - * (maintenance), % (percent), ppm (parts per million), lbs/A (pounds per acre), lbs/1000 sq. ft. (pounds per 1000 square feet), mmhos/cm (milli-mhos per centimeter), meq (meq/100g: milli-equivalent per 100 grams)

Comments:

~ NITROGEN: Apply 20-30 LBS of N per acre in the fall to aid establishment, and apply another 90-125 LBS per acre in the spring, depending on residual nitrogen levels. This spring application should be split, with the first application at green up, and the balance at growth stage 6. ~ SULFUR: Apply 10-15 LBS per acre at planting, followed by another 10-15 LBS per acre around growth stage 6 in the spring.

Figure 16. Soil samples collected after harvest (1-control, 2-litter, 3-inorganic fertilizer)

Conclusions

Inorganic fertilizer and poultry litter are two common wheat fertilizer options used in North Carolina. With the increased price of conventional inorganic fertilizer, poultry litter is being considered and used as a cheaper alternative. In our study, there was no statistical difference in yield between using poultry litter and inorganic fertilizer. As for nutrients, there was a higher level of phosphorus and potassium in the litter treatments and a higher level of these nutrients in the ground after harvest as well. The late frost that occurred during April 2022 could be a reason why the inorganic fertilizer plots did not have a higher yield but this cannot be known without further examinations. Both poultry litter and inorganic fertilizer seem to have shown consistent nutrient uptake and yield results during this study. Poultry litter seems to be a promising alternative to just using inorganic fertilizer as a fertilizer option for wheat production.

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