Residual Effects of Pelletized Poultry Litter on Cotton Leaf Area Index, Nitrogen Uptake and Lint Yield

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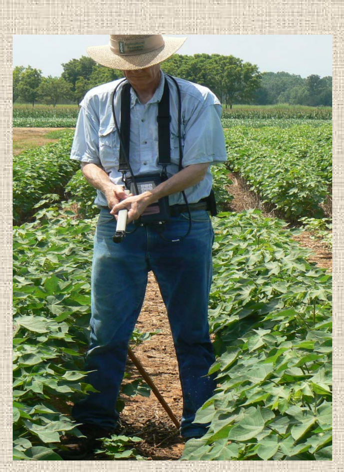
Pelletized Poultry Litter and Sub-surface Banding of Pellets after Planting using a GPS-equipped Tractor



Above-canopy Measurement

Four Below-canopy Measurements Parallel to the Row and at 0, ¼, ½, and ¾ the Distance in Middle

Measuring Leaf Area Index – LAI-2000 Plant Canopy Analyzer Fitted with a 270° View Cap on Radiation Sensor

Rationale and Objective

The incorporation of pelletized poultry litter (PPL) into soil retains more organic nutrients in the root zone, helping to improve soil quality. Because only a fraction of N in PPL becomes available in the year of application, the residual effects (carryover) of litter fertilization may provide long-lasting plant growth benefits after applications cease. Additionally, using PPL to meet some of the N requirements of upland cotton (*Gossypium hirsutum* L.) can reduce fertilizer costs and potential losses of NO_3-N in surface and ground water.

Knowledge of crop ecology, yield and N utilization responses as a function of residual PPL is needed to address concerns over best litter management practices and rising costs of N fertilizer in crop production. Objective was to determine residual effects of sub-surface band applications of 6.7 Mg PPL ha^{-1} on cotton leaf area index (LAI, leaf area per unit ground area), N uptake and lint yield.

Materials and Methods

- Cotton (cv. PHY 375 WR) was grown at the R. R. Foil Plant Science Research Center at MSU. Soil was mapped as a Marietta fine sandy loam (fine-loamy, siliceous, active, thermic Fluvaquentic Eutrudept).
- Four fertility treatments were replicated four times and each strip-plot experimental unit was 28 m long with six, 0.97-m wide rows.
- Treatments were as follows: residual PPL in which 6.7 Mg ha^{-1} (~220 kg N ha^{-1} yr^{-1}) was applied as a sub-surface band 30-d after planting in 2010-2013; residual PPL with 84 kg N ha^{-1} as urea-ammonium nitrate at squaring stage (36-39 DAP); N fertilization of 56 kg N ha^{-1} at planting plus 84 kg N ha^{-1} at squaring stage; and no N (control).
- Leaf area index and diffuse non-interceptance (DIFN, the fraction of sky not blocked by foliage) were measured using a method for homogeneous canopies (Li-Cor, 1992; p. 4−16). Leaf reflectance and transmittance of light in direct sunlight can result in underestimation of LAI. Therefore, measurements were made between 1700 and 1900 h.
- At open fruit (boll) stage, plants from a 0.289 m^2 area in a central row were cut at the soil surface and the seed cotton removed by hand. The remaining leaf, stem, and fruiting materials were dried for determination of dry matter and ground to pass a 1-mm screen. Total N was determined by dry combustion using a ThermoQuest C/N analyzer (CE Elantec, Lakewood, NJ). Crop N uptake (kg ha^{-1}) was expressed as the product of dry matter and N concentration.
- Seed cotton was harvested from four central rows using a CASE IH 1844 spindle picker retrofitted with a weigh basket (± 0.02 kg). Gin turnout [lint wt./(wt. of lint + seed + trash)] was determined from 1.0 kg subsamples and values used to adjust seed cotton yield to lint yield.

Properties of initial soil (0−15 cm) and pelletized poultry litter applied to cotton in 2010−2013.

	pH	Total C	Total N	NH_4^+-N	NO_3- N	P	K	Ca	Mg	S
				--- g kg^{-1} ---						
Initial soil	7.7	15.1	0.8	0.002	0.017	0.08	0.22	6.01	0.07	----
PPL	8.0	300.0	33.0	3.04	0.92	12.0	23.5	20.3	5.8	5.9
				--- kg ha^{-1} ---						
Avg. rate	----	1993	221	20	6	80	158	155	41	38

Li-Cor Corporation. 1992. LAI-2000 Plant canopy analyzer: Operating manual. April 1992 ed.

Muharam, F.M., K.F. Bronson, S.J. Maas, and G.L. Ritchie. 2014. Inter-relationships of cotton plant height, canopy width, ground cover and plant nitrogen status indicators. USDA-ARS/UNL Faculty. Paper 1474. http://digitalcommons.unl.edu/usdaarsfacpub/1474

Boquet, D.J., and G.A. Breitenbeck. 2000. Nitrogen rate effect on partitioning of nitrogen and dry matter by cotton. Crop Sci. 40:1685-1693.

Results

Management and environmental conditions in 2014−2016.

Year	Plant	UAN	Hand harvest	DD60†	Rainfall†	Defoliate	Machine pick
2014	24 May	2 Jul	18 Sep	2258	392	26 Sep	16 Oct
2015	13 May	18 Jun	14 Sep	2297	289	22 Sep	2 Oct
2016	19 May	24 Jun‡	9 Sep	2377	213	21 Sep	6 Oct

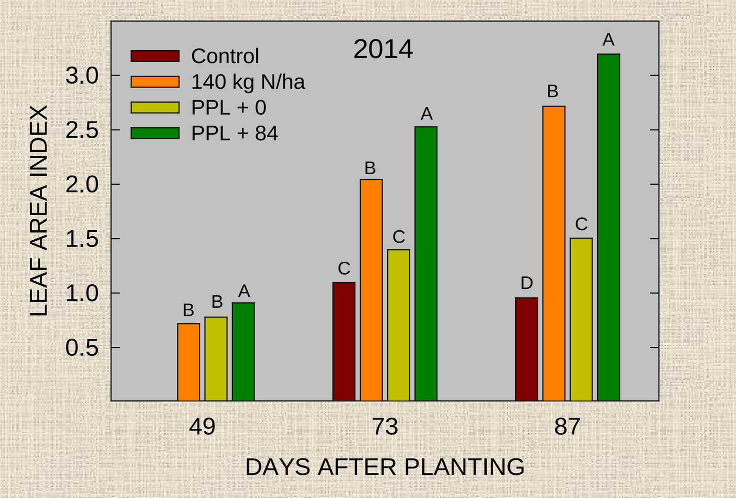
† DD60 = cumulative degree days with 15.5 °C base temperature from planting to hand harvest; rainfall (mm) = seasonal total from planting to hand harvest.

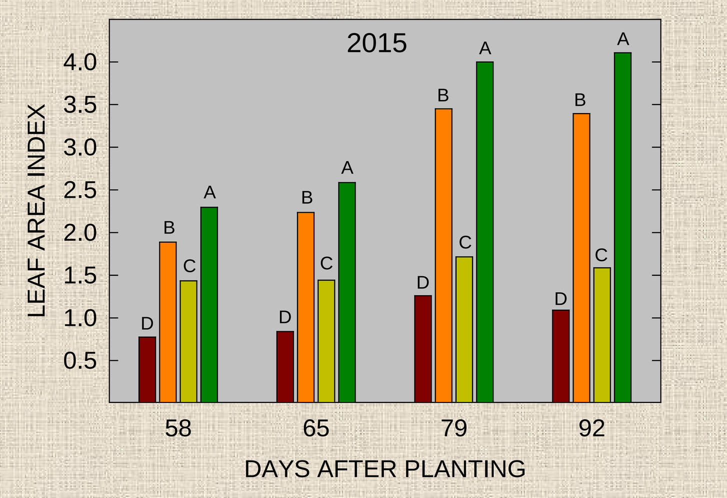
‡ Side-dress N rate was 56 kg ha^{-1} in 2016, somewhat less than 84 kg N ha^{-1} in 2014 and 2015.

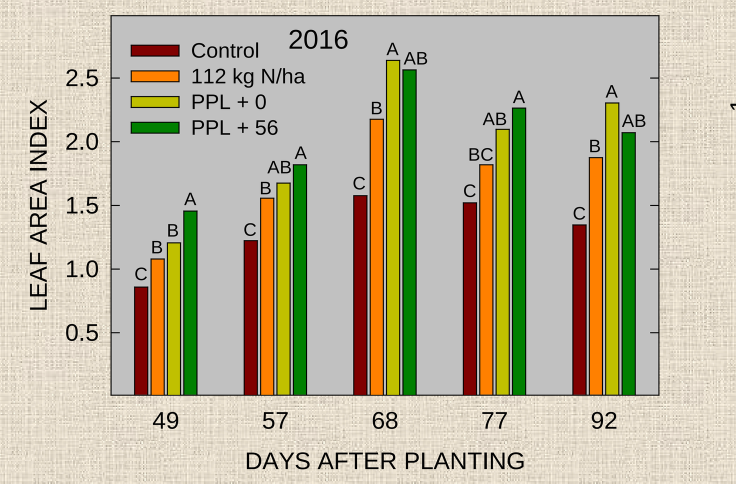
Plant Canopy Parameters and Machine-Harvest Lint Yield

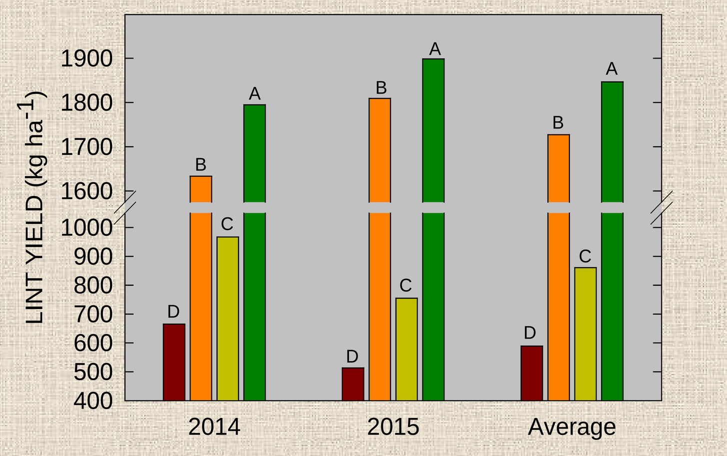
Supplementing residual PPL with 84 kg N ha^{-1} at squaring significantly boosted LAI during boll-filling in early August (73-92 DAP) and resulted in LAI large enough (>3) to cause canopy closure. Accordingly, this treatment had the greatest lint yield in 2014 and 2015. In both years, LAI was greater in plants fertilized with 140 kg N ha^{-1} than residual PPL only. Residual PPL with or without supplemental N sometimes boosted LAI in 2016 when growth was limited by droughty conditions.

Based on DIFN values in early August, "canopy light absorption" in PPL + 84 kg N ha^{-1} treatment was approximately 86% in 2014 and 94% in 2015. Additionally, light absorption in this canopy was 3–6% greater than in plants provided 140 kg N ha^{-1} and was 21, 24, and 2% greater in 2014, 2015 and 2016, respectively, as compared with plants provided residual PPL only.



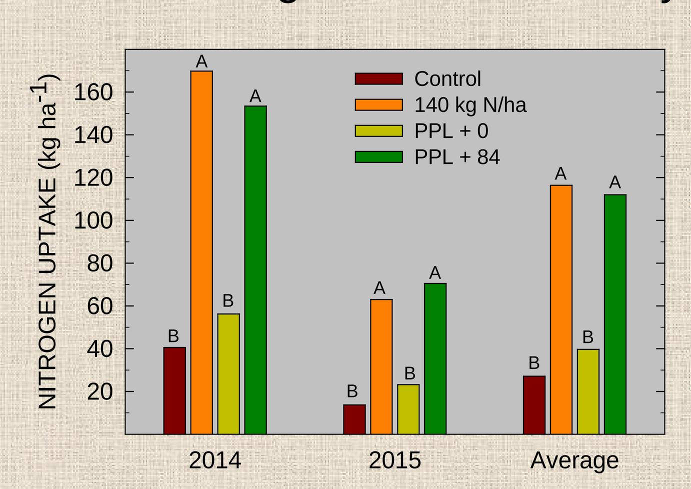


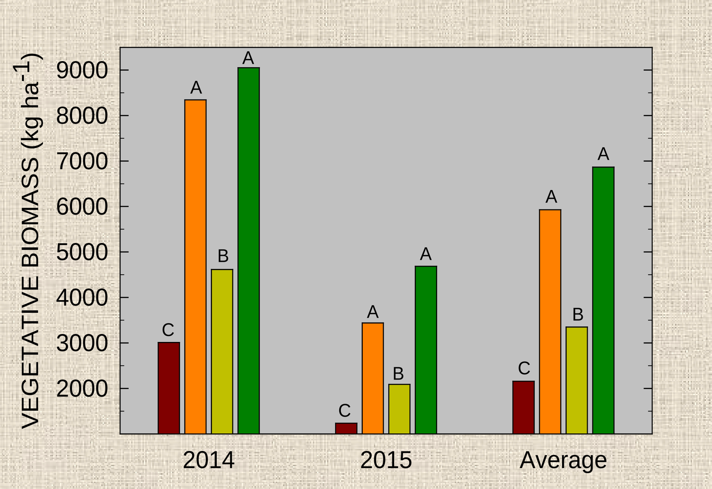




Nitrogen Uptake and Biomass in Vegetative Material

As expected, N uptake and biomass were responsive to N fertilization. Greater N uptake in 2014 than 2015 was associated with increased biomass and approximately 2.0–2.4 g kg^{-1} greater N concentration (data not shown), depending on fertility treatment. Despite the observed difference in agronomic traits, lint yield was similar in 2014 and 2015.





Simple Correlation (r) Based on Individual Plot Values

Nitrogen uptake increased as LAI increased and this association was somewhat stronger in 2015 than 2014. This is consistent with Boquet and Breitenbeck (2000) who reported leaf blades most consistently reflected the amounts of fertilizer N applied to cotton in Louisiana.

In both years, N uptake had a strong association with lint yield, particularly lint harvested from four central rows (r=0.86–0.90). Similarly, values for LAI had a stronger correlation with yield of four central rows than yield of 30-cm row length. Nitrogen fertilizer is known to increase leaf number and leaf area, plant height, number of nodes, number of bolls, and individual boll weight (Muharam et al., 2014). On the other hand, N deficiency in cotton limits yield through decreased leaf area expansion and CO_2 assimilation capacity.

Correlation matrix for LAI on 5 August, LAI on 19 August, plant N uptake, lint yield of 30-cm row (LntYld-30) and lint yield of four rows (LntYld-4R) in 2014.

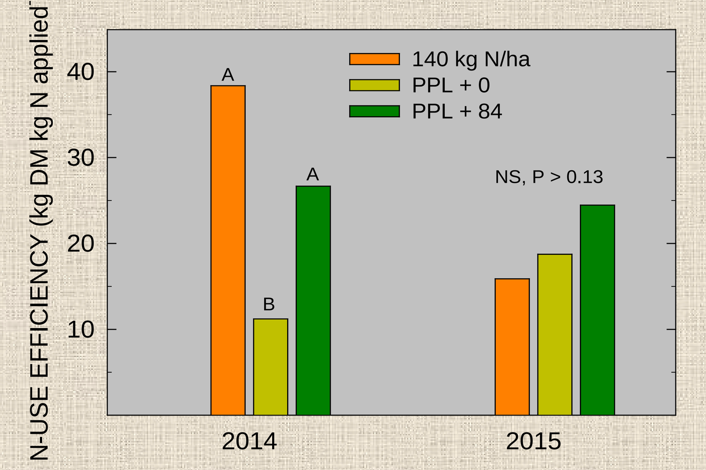
Parameter	LAI-5 Aug	LAI-19 Aug	N uptake	LntYld-30
LAI-19 Aug	0.96			
N uptake	0.77	0.85		
LntYld-30	0.55	0.69	0.80	
LntYld-4R	0.92	0.99	0.86	0.70

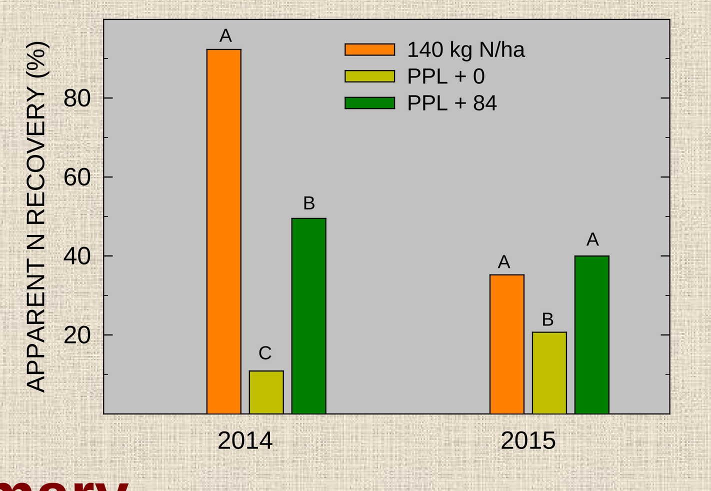
Correlation matrix for LAI on 31 July, LAI on 13 August, plant N uptake, lint yield of 30-cm row (LntYld-30) and lint yield of four rows (LntYld-4R) in 2015.

Parameter	LAI-31 Jul	LAI-13 Aug	N uptake	LntYld-30
LAI-13 Aug	0.99			
N uptake	0.92	0.92		
LntYld-30	0.73	0.72	0.88	
LntYld-4R	0.95	0.94	0.90	0.83

Nitrogen-use Efficiency

Adjusted for N uptake in controls and assuming a 40% carryover of residual PPL N, crop N recovery generally was greater in the 140 kg N ha^{-1} and residual PPL + 84 kg N ha^{-1} treatments than residual PPL only.





Summary

- Beneficial effects on leaf area index, lint yield and N-use efficiency were evident in two growing seasons after PPL applications ceased.
- Canopy structure differed (P<0.01) between residual PPL treatments in early August. On average, 28% of the sky was visible from beneath the residual PPL only canopy and 13% was visible from beneath the PPL + 87 kg N canopy.
- The residual effect of PPL supplemented with 84 kg N ha^{-1} increased (P<0.01) lint yield by approximately 10% in 2014 and 5% in 2015, as compared with standard fertilization practice of 140 kg N ha^{-1}.
- General observations suggest N availability from applying 6.7 Mg PPL ha^{-1} in 2010-2013 was at least 56 kg N ha^{-1} in the two years after applications ceased.

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